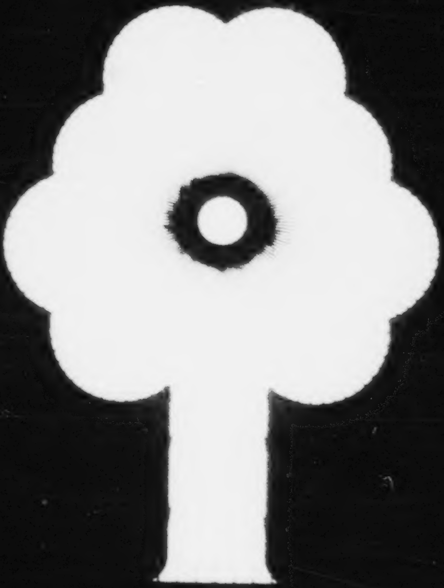

Managing the Legacy

Proceedings of a
Colloquium on the Environment,
December 1985

Sponsored by the Economic Council of Canada

86-04942/

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Proceedings of a Colloquium on the Environment,

December 1985

A collection of papers presented at a colloquium sponsored by the Economic Council of Canada. Although this volume is published under the auspices of the Council, the views expressed herein are those of the authors and, as such, have not been endorsed by Members of the Economic Council of Canada.

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Available in Canada through

Authorized Bookstore Agents
and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Ottawa, Canada K1A 0S9

Catalogue No. EC22-131/1986E
ISBN 0-660-12056-9

Canada: $9.95
Other Countries: $11.95

Price subject to change without notice

Ce rapport est également disponible en français sous le titre : *Préserver l'héritage écologique*.

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Managing the Legacy

1 Introduction

Presentation by Judith Maxwell

Over the years, Canadians have become increasingly aware of the seriousness of environmental issues. Environmental problems are occurring more frequently, in wider variety, and in greater complexity than ever before. They are challenging the determination and ingenuity of scientists, business, and government policy makers. Just as economic activity gives rise to environmental damage, so policy responses to actual or potential damage in turn affect economic activities. Either way, they can be very costly. Yet man-induced environmental changes are inevitable, with profound consequences for our economic options in the future.

Today, we are well beyond the somewhat sterile arguments that traded off economic growth against the concerns for the environmental quality of life. There is now a broad recognition that economic activity in its many forms takes place within the broader domestic and global environment and must be responsive to the complex ecological interrelationships that nature weaves. We have come to appreciate more and more the linkages between man's activity and its effects on the food chains, climate, and the life-giving supplies of oxygen, water, and nutrients.

In this broader context, the discipline of economics often has difficulty coming to grips with the complex scientific and other relationships that affect the location and movement of natural resources. Consequently, in confronting the growing number of environmental issues there must be a joining of disciplines. To the extent that decisions involve the allocation of effort and resources, economists have a role to play. But economics can only be useful if it is combined with contributions from other disciplines. Science, law, engineering, and administration all have an equal or stronger role to play.

Environmental policies, in many cases, have been a form of management by crisis, often requiring massive remedial expenditures. Today, more emphasis is being given to building in the clean technology because it is usually less costly to anticipate and prevent damage than it is to clean up afterwards.

Preventing or reacting to environmental degradation does not come cheaply. For the majority of OECD member countries, environmental expenditures, both public and private, may account for as much as 2 percentage points of gross domestic product. If the figure for Canada is anywhere close to that level, it could mean up to $8 billion in expenditures annually. This is close to what we now spend on higher education and could be one-quarter of Canada's gross annual investment expenditures.

In the face of such large outlays, we owe it to ourselves to ensure that we are as cost-effective as possible in meeting our environmental objectives. We must recognize that there are alternative ways of managing resources, resolving conflicting claims, and reducing pollution. By using the most efficient techniques to do the job, we free resources to contribute to our other social objectives, including economic growth.

If environmental policies require scrutiny from the perspective of economic efficiency, so should economic development policies be judged on their environmental soundness. Many well-intentioned initiatives designed to improve living conditions and promote development can have environmental consequences that, over the long haul, may prove disastrous. All of us are aware of such cases, particularly those which have occurred in Africa and Latin America, where fragile tribal cultures and local economies are especially vulnerable to drought, soil erosion, overgrazing, and other ecological destruction.

Few economists have the capacity to anticipate all the longer-run consequences of development. The reason for this is fairly clear. In western societies, most economists are used to relatively competitive markets within which goods and resources are allocated by the price mechanism through a system of voluntary exchange. In this framework, there is a jurisdiction that governs how transactions take place. There is also a system of property rights and legal liabilities. Where transactions occur, it is not too difficult to identify costs and benefits. But in the wider framework that embraces environmental concerns, our industrial societies produce massive amounts of residual wastes that go into the prevailing airsheds or watersheds, or work their way through the soil. Here, there are no priced transactions *per se*. Pollutants are mobile. They flow and interact with other substances in ways that are not fully understood. Often, multiple pollutants are involved. Many have toxic properties. And some in their interaction may become even more hazardous.

In many cases, not much is known about the relative risks to human health or life. The risks may vary, depending on whether populations are concentrated or scattered. And this situation may be worsened because the legal system cannot cope with the complexities in order to provide either redress or deterrence in the event of harm. In this setting, it is unlikely that traditional market mechanisms will provide efficient environmental protection. Direct government regulation may be necessary.

Another aspect of the failure to integrate economic and ecological concerns is the measurement problem. Many of the benefits of environmental interventions escape macroeconomic interpretation, since statistical calculations of "avoided damage" are not easily come by. The Economic Council's 1981 report on *Reforming Regulation*, observed that "the qualitative benefits to life that (these) regulations were designed to foster do not enter into the quantitative calculations of gross national product. Hence if Canadians collectively prefer healthier, safer and esthetically more pleasing environments . . . they may be better off and yet appear worse off by national accounts measurements."

While the case for meshing the knowledge and expertise of different disciplines is compelling, there must be effective communication in order to identify problems and solutions. Different problems, after all, usually require different solutions. One set of environment problems includes those activities which are intended to prevent damage or harm to human health and safety. A second set of problems is quite different. It involves the job of managing common-property natural resources and reconciling the existing claims upon those resources so as to conserve or improve their environment. We see examples of this in the administration of renewable resources such as fish and game stocks and public forests, where the common-property characteristic requires that public access be rationed and that yields be sustained.

In dealing with a specific environmental problem, a number of considerations emerge. First, the problem must be anticipated and identified: What conditions are unsatisfactory? What agents are causing the damage? And how and why are they occurring? Then there is the choice of preventative actions, which may range from simply informing the parties involved to an outright ban or closure. Then there may be various forms of monitoring needed to ensure continuing compliance, with appropriate sanctions in the case of violations. If damage has occurred, there is the responsibility for remedial action – who must undertake it and who must pay for it. And finally, there is the question of compensation to the victims, whether there is adequate insurance on the one hand, or whether there is a fair and equitable means of obtaining redress through the legal system, on the other. Solutions that employ economic incentives may well have a place in these matters, but they must be buttressed by scientific knowledge and the law, and by corporate responsibility and public awareness.

It was out of a concern that environmental issues be dealt with as effectively as possible that the Economic Council sponsored a Colloquium on the Environment in Toronto in December 1985. Approximately 100 persons were present whose expertise extended well beyond the realm of economics and engaged scientific, administrative, legal, and engineering disciplines, along with industrial experience. A number were associated with international organizations. The Colloquium was made up of seven sessions, each involving the presentation of a lead speaker, comments by two panelists, and a general discussion. The Colloquium sessions, together with the address of the invited dinner speaker, Camille Dagenais, Chairman of the SNC Group, Montréal, constitute the substance of this book.

In addition to the formal papers and discussion, the Colloquium heard from the Honourable Tom McMillan, Minister of the Environment in the federal government, and the Honourable Jim Bradley, his Ontario counterpart. Both emphasized the growing importance that their respective governments attach to environmental issues, as well as their determination to work with other governments, the private sector, and the public at large, to preserve and enhance the environment. On behalf of all the Colloquium participants, let me express my deep appreciation to these gentlemen and to the other invited speakers and discussants.

The proceedings, reported here, provide an assessment by some eminent authorities of where we stand in environment issues and where we are headed. The papers that follow attempt to outline a sound perspective on such questions as:

- how global environmental concerns relate to people in various parts of Canada;
- how resource exploitation can be made more compatible with renewal;
- how to achieve the proper allocation of responsibility in a society that uses a plethora of toxic substances; and
- how economic analyses and decision making can better incorporate environmental values.

Together they confirm the need for multidisciplinary research, for an informed public, and for private initiatives if we are to succeed in preserving and managing the legacy that awaits our children.

2 International Perspectives

Presentation by James W. MacNeill

The Economic Council reflects the highest standard of excellence in everything that it undertakes, and I would like to commend Judith Maxwell, David Slater, and their distinguished colleagues for taking the initiative to convene this symposium with its focus on the relationships between the environment and the economy.

There is an old saying that our relations are given but, thank God, we can choose our friends. The environment and the economy are closely related – they have no choice. And frankly, it is high time that they become friends. More than friends. They are in bed together, and I hope that the Economic Council, guided by this Colloquium, will play the long-overdue role of marriage broker – if that's not too old-fashioned an idea – and even though both parties may prefer living in sin.

We have come a long way in the past two decades in our understanding of the relationships between the economy and the environment, and it is clear that, as a marriage broker, the Economic Council would be serving the interests of both parties. Most of what we know today about these relationships stems from the work of individuals in institutes and universities supported by foundations. Some of those individuals are here, and I would like to commend them for their efforts.

The OECD has done a lot of work among industrialized countries, over the last few years, and in 1984 it brought this work together in an International Conference on Environment and Economics, which some of you attended. As for developing countries, almost no work has been done. Yet, in Africa, Asia, and Latin America, as the world knows from watching television, these issues are almost primordial.

Trends in Developing and Developed Countries

If you compare the OECD's recent *State of the Environment Report* with those emanating from the United Nations and some developing countries, you will find that during the past 15 years only a few countries have managed an improvement in the quality of their environment and the ecological basis of their development and that they are all rich, industrialized countries, like Canada.

Developing countries simply have not been able to afford the costs of the react-and-cure policies that have dominated approaches to environmental management in the industrialized nations. Most of them have experienced a massive deterioration of their environment, with problems associated with sudden industrialization and explosive urbanization being added to those associated with underdevelopment and poverty. Take Brazil and Indonesia, for example, two countries that hosted meetings of the Commission this year. The ecological surplus with which they were blessed is being consumed at an increasing rate. It is not being replaced. Talking in terms of balance sheets, we could say that many developing countries are in deeper ecological debt than financial debt; and, as the world now knows, some countries in Africa have used up virtually all of their reserves.

We are today witnessing unprecedented pressures on the environment and the resource basis of development, and we are entering a period when those pressures will increase at rates never before seen in history. The world economy has now passed the $15 trillion (U.S.) mark, and in most respects it is 10 to 100 times larger than what it was a hundred years ago. Fortunately, this does not mean that a 1 per cent increase in production has 100 times the impact on our environment that it did a hundred years ago – the relationships are not linear – but it probably approaches that range.

Take one area alone, that of environmental pollution. At last year's Conference on Environment and Economics, three scenarios were considered in the OECD area. In the first, standards were tightened in pace with slow-growth assumptions of 1 to 3 per cent. This was designed to keep emissions of conventional pollutants to their 1978 levels, and pollution control expenditures showed an increase of over 100 per cent by the end of the 1990s.

In the second scenario, standards were not tightened in pace with growth, and pollution was allowed to increase substantially. With it came increased damage to health, property, and ecosystems, but pollution control expenditures increased by only 20 per cent in real terms.

A third scenario recognized the significant advances that have been made in environmentally favourable product designs (in automobiles, for example), in industrial processes and recycling (in chemicals, for example), and in emission control technologies (in fossil fuel combustion, for example). Many industries have introduced these advances to the benefit not only of the environment but also of their balance sheets. This scenario assumed a continuation of this trend, along with environmentally favourable changes in the structure of economic activity and more effective and more efficient policies and institutions. It implied that, at one and the same time, standards could be tightened, emissions could be reduced, and increases in control costs could be constrained.

This third scenario was obviously a comforting one to those advanced industrialized countries which may be in a position to project it. But some of the assumptions underlying it are crucial; and, in my view, the most crucial are those concerning more efficient and more effective policies and those concerning institutional change. The pressures on the planet's environment and resources today are nothing compared to what they will be over the next 20 short years, when the world economy could double again, and over the next 30 to 40 years, when a whole extra world of people and their demands will be imposed on the present one. If we are to manage that – even muddle through without a major catastrophe – significant changes will be required in the ways in which we integrate the environment and the economy, including institutional arrangements for that purpose.

The Commission

This was one of the major considerations, I believe, that led the General Assembly of the United Nations to consider a special commission to take a fresh look at the evolving situation. By the end of 1983, when the General Assembly had adopted a resolution calling for the establishment of the World Commission on Environment and Development, governments had agreed that it should do two things. First, it should take a fresh look at the critical issues of environment and development from a perspective that offered some promise of practical proposals for action. Second, it should examine forms of international cooperation on these issues and propose means of strengthening them and making them more effective. Finally, recognizing that the system is not renowned for self-examination and reform, the General Assembly agreed that this examination had to be undertaken outside the U.N. system rather than within it, by a body independent of the system but with clear links to it. Hence, the commission is independent, but the General Assembly has undertaken to receive and debate its report and recommendations in the fall of 1987.

We are currently in the last six months of our fact-finding phase, having met in three regions and four countries over the past year (Switzerland, Indonesia, Norway and Brazil). Through public hearings and other means, we are trying to tap the ideas of leaders from all walks of life – institutes, industry, and governmental and nongovernmental organizations.

The commission is looking forward to its next meeting here in Canada in May, when our hosts will be the Government of Canada and several of the provinces. In fact, the plans I have seen include meetings with leaders in all of the provinces from government, industry, institutes, and NGOs. There will be two days of public hearings and a number of other events to expose the commission to Canadian views on the issues.

The Canadian meeting will mark the end of our fact-finding phase. The commission will then take about six months to put together its report and recommendations, which should appear around March of 1987. We then plan an intensive series of events, including consultations with governments on the recommendations, leading up to the U.N. General Assembly in the fall of 1987.

The objective of the commission's strategy is *change* – in the way we look at the issues, in the policies through which we address the issues, and – to the extent that change is necessary – in the institutional framework for international cooperation on the issues.

Some Successes to Build On

In all of this, we shall be asking ourselves what has gone wrong. But we shall also bear in mind that some parts of the world, including Canada, have registered some significant success in improving environmental quality over the past 15 years.

All of us here who can remember the environmental destruction that accompanied the rapid growth of the 1950s and 1960s can confirm that there have been successes. In those days, if you fell in the Thames they pumped out your stomach, just in case. One London smog killed some 4,000 people.

In the late 1960s the Swedish lakes were thought to be in their death throes from eutrophication. As for Lake Erie, it was pronounced dead; some said irreversibly dead. A lot of Americans remember the great river fire: someone threw a match into the Cavayahuga, a tributary of Lake Erie, and it burst into flames.

Thanks to Rachel Carson and many others, environmental awareness began to grow, driven by a gradual shift in values and, some think, given an extra push by colour television, which came to North America in 1965. A red or yellow plume pouring out of a factory chimney into clear blue sky or water is much more dramatic in colour than in black and white. In any event, public opinion demanded action and governments responded with new legislation, institutions, policies, and programs. The rest is familiar history, marked by a number of significant improvements in environmental quality.

Canada and the United States signed the Great Lakes Treaty in 1971 and today, billions of dollars later, Lake Erie, like Lazarus, has risen. It is still wounded, but it is not dead. The same is true of the Swedish lakes. Many rivers are clean and alive. Some years ago, the Thames produced the most famous salmon in all of history. Air quality has improved in many areas. The Japanese can see Mount Fuji again, and Los Angelenos can see each other again – at least on most days. We have more parks. And many cities are more livable, with malls, pedestrian precincts, and all kinds of "people places" like Harbour Front, here in Toronto.

Unfinished, New, and Broader Agendas

But the progress of the past decade and a half in clearing up the backlog of environmental damage has been spread unevenly throughout the industrialized world and, as I mentioned, has hardly touched the developing world. It has left a long unfinished agenda: acid rain; water pollution, especially from nonpoint sources; chemicals; hazardous wastes; industrial accidents – the list is familiar to you.

At the same time, we have also acquired a longer and much broader agenda of new issues, more complex than those presented by conventional pollution and implying heavier social and economic costs, whether action is taken or delayed. Many of them are related to economic, trade, agriculture, and forestry policy – including soil erosion and desertification, forest depletion and the loss of the planet's biological diversity, which is essential to maintaining the genetic strength of the world's principal food crops. Many are related to energy policy – climatic change, for example, which (if the scientists are right) could produce massive physical, economic, and social consequences before the middle of the next century, within the next 40 to 65 years.

Questions of environment that were once thought to be rather straightforward are now seen to be highly complex. They involve linkages and feedbacks among economic, agricultural, energy, forestry, transportation, and trade policy. They raise questions of economic gain in the short term versus unsustainable development and economic loss and social dislocation in the medium and longer terms.

Interdependence has emerged as a dominant characteristic of many of these issues. From 1962 to 1984, the world's exports rose from 12 per cent to 22 per cent of total output. Canada has traditionally been heavily dependent on international trade, but even in the United States – which has not been so dependent – exports rose from 6 per cent of GNP in 1962 to 13 per cent in 1981, before retreating in the face of an overvalued dollar. With exports rising as a fraction of GNP, the world is becoming more and more economically integrated – and ecologically interdependent.

This has long been evident between Canada and the United States, where growth in one country has impacted visibly on the environment of the other – both directly in the form of physical pollution spilled over into the other through our common airsheds and watersheds, and indirectly through the trading system, with increased demands in one country translating into higher levels of production in the other for energy, resources, food, and manufactured goods.

We have long known that, because of the nature of our closed planetary ecosystem, many physical spillovers have a global reach – some persistent chemicals, for example. And we now know that through our trading system, higher levels of consumption in one region may quickly translate into increased pressures on the environment of another, more distant, region. Prairie soils, for example, have not escaped the pressures generated by the food needs of a growing and more affluent world population. The recent report on *Soil at Risk* by the Senate Standing Committee on Agriculture, Fisheries and Forestry was aptly subtitled *Canada's Eroding Future*.

Agriculture and Environment

Indeed, agriculture is one of the best examples of a sector for which policies have been designed year by year to secure short-term gains in production and profitability, but without regard to their longer-term environmental and economic consequences. As documented by the Senate Standing Committee, these consequences are proving to include lower soil productivity, higher costs, and lower returns. According to the Senate committee, Canada "is facing the most serious agricultural crisis in history. Soil degradation is already costing Canadian farmers $1 billion per year in lost farm income, and we are clearly in danger of squandering the very soil resource on which the agricultural industry depends." Referring to the problem in the Prairies, the committee observes that "the current agricultural system is obviously not a sustainable one. We are effectively 'mining' the soil and are about to reach (in some cases have already reached) the point where the soil is mined out."

The source of the offending practices, documented by the committee, is largely the unintended environmental effects of well-intentioned economic subsidies of one kind or another, which, quoting again from the report, "encourage the drainage of wetland or sloughs to create marginal cropland; force farmers to cultivate marginal land intensively for the cash it will return;

and do not differentiate between productive and nonproductive land."

U.S. and European reports tell a similar story. Nitrate pollution of groundwater is a serious problem in Europe, with potentially enormous economic consequences. It stems largely from the overuse of fertilizers, which qualify for subsidies regardless of whether the land drains into an acquifer or not. Groundwater depletion is another problem that is often encouraged by subsidized irrigation, crop, and water-pricing policies.

This year for the first time, the European Community Commission's Green Paper on the Common Agricultural Policy (CAP) includes a chapter on "Agriculture and the Environment." In it they suggest a number of measures both to control agricultural practices harmful to the environment and to promote practices that will enhance the environmental basis of agriculture. It is an interesting commentary on CAP – and perhaps on the strength of the European farm lobby – that they don't propose removing or even fine-tuning the subsidies that induce the offending practices; instead they propose increasing them, this time in the interest of conservation!

It is not too well known but the U.K. government tops up CAP subsidies by about an equal amount and a few years ago, according to *The Economist*, the Central Policy Review Staff highlighted the damage being done to the environmental basis of U.K. agriculture and to the countryside. It produced numbers showing how the government could, at one and the same time, effect a large reduction in public expenditure, reduce food prices, and benefit the fundamental basis of future agricultural productivity. A neat hat trick that is well within the grasp of many OECD member governments, including I dare say, the Canadian government. The Senate committee observes that its figures on the cost of soil degradation are incomplete in themselves and also "do not reflect the total cost of the problem to the Canadian economy." But it doesn't refer to any studies of the total cost to the Canadian economy, perhaps because none exist.

Integration of Environment and Development: The Additionality Syndrome

Some of us will remember that when the notion of reconciling environment and development was first put forward at the Stockholm conference in 1972, it was considered revolutionary. Indeed, the conference was barely able to contain the fears and suspicions of developing countries that a worldwide concern for the environment threatened their development prospects. Their password, taken from the experience of the rich countries in the 1950s and 1960s, was: Development first, and the environment later, when we are richer.

The OECD adopted its famous "polluter-pays principle" in 1972, but it was not until 1979 that it formally concluded that economic growth and environmental management were both essential, interdependent, and reinforcing goals – a conclusion that was repeated in stronger language in 1984, and again this year.

At the same time, in 1979 the OECD called upon governments to adopt measures to integrate environment and economic development at the earliest possible stage, not only in three-dimensional projects but also in the formulation of policies and programs.

That call has been repeated by the OECD many times since. And in the Third World today, as our meeting in Brazil testified, those who led the thesis of "development first and environment later, if ever," are changing their minds – in both cases, for what they then thought, and now think, are hard-nosed economics imperatives.

In the light of this, I would like to raise a question for this colloquium. It is simply this: Why – given our growing knowledge, awareness, even consensus – why have we been so slow to effectively integrate environment with economic and social development? Why does it occur so seldom? What are the principal constraints and roadblocks? And what can be done about them?

Many of you have thought about this. Some of you, I know, have tried to do something about it and have some answers.

While there are many reasons, in my view there is one overriding reason – perhaps a sort of three-in-one. It is what I would call the "additionality syndrome" that has dominated virtually all attempts at environmental management since the late 1960s and early 1970s. The additionality syndrome is reflected in just about everything that we have done and are doing about the environment; it is reflected in our add-on institutions, our add-on policies, and our add-on technologies. It is embedded in our treatment of the environment as an add-on politically. Underlying all of these add-ons – and more important than any of them – is the early view, slowly changing, that the environment is an add-on economically.

Environmental Institutions – An Add-On

At the end of the 1960s, the task was to clean up the mess left by 20 years of rapid and unrestricted postwar growth. It was therefore normal at the beginning of the 1970s, when most of the environmental agencies were created in industrialized countries, that they were simply tacked on to the existing structure. They acquired mainly scientific staffs – little was known about the phenomena – and they were mandated to focus largely (and often only) on the effects of activities impacting on man or the natural environment.

They were seen to have a role separate and distinct from development, a role reflecting a very narrow interpretation of environmental policy, related directly to the treatment of air and water pollution and to the conservation of nature, parks, and species. They were asked to deal with the symptoms – ameliorating environmental damage – because these symptoms had got out of hand. They were given no role at all in the formulation or assessment of economic, energy, agricultural, industrial, or other policies.

Yet, as we know today, these policies are the real "environmental policies," influencing fundamentally the form, character, and distribution of the positive and negative impacts of economic activity on resources and the environment. Central economic and sectoral policies were, and still are, taken generally as a given. Development programs and projects were also taken largely as a given, at least until environmental-impact assessment processes came in, but even they were, and are, an add-on rather than a build-in.

The initial mandates of some of these agencies are case studies in turf definition. In a few cases, their founding legislation or executive orders state, in one way or another, that apart from the responsibilities explicitly given to them for the protection of air, water, reserved lands, and so on, the responsibilities for policy, research, and coordination shall include everything *not already assigned to any other agency*. Which didn't leave much room for manœuvre.

React-and-Cure Strategies

Some environment agencies have managed to modify their mandates, often in ingenious ways. But most must still view environment policy as a limited field, essentially an add-on to other policy fields. Their prime mission, today as yesterday, is to react to damage already done and to treat the symptoms after the fact.

As the record shows, many have done a remarkably good job of that. Indeed, even if their mandates were to remain as restricted as they are now, environment agencies would need to be strengthened in all countries – and internationally. Most of the unfinished agenda of the past decade and much of the new agenda will require react-and-cure strategies. Hopefully, they will be more efficient than present strategies and more effectively delivered by stronger institutions, but, in any event, they will be needed.

Internationally, too, the need for such strategies is growing rapidly. Last year, the Swedish Red Cross Society came out with a landmark study called *Natural Disasters: Act of God or Acts of Man?* It found that the number of disasters worldwide increased each year, from 54 in the 1960s to 81 in the 1970s. It demonstrates clearly that, given future disasters already in the pipeline of population growth, poverty, and maldevelopment, the overall situation is going to get worse before it gets even worse.

A few months ago, in Indonesia, I was talking with industrial leaders, including the local heads of several multinationals. They told me that within days of Bhopal they had received instructions from their head offices to review all environmental and safety procedures and report back. There is no doubt that as a result of Bhopal the famous corporate "bottom line" has come to include more environmental and safety measures than ever before. It has also come to include a healthier attitude towards cooperation on these issues with governments and among industries. In a moment of candour, one industry leader said to me "You know, Mr. MacNeill, tomorrow's Bhopals are engraved in yesterday's decisions, in my industry and others. I hope we can find them and correct them before they find us." Is this not an echo of our experience with hazardous wastes over the past decade?

Anticipate-and-Prevent Strategies

Given all the trends, it is clear that react-and-cure measures will remain an essential and growing part of public policy. But they are clearly not sufficient. Unless they are rapidly reinforced by anticipate-and-prevent measures, it is doubtful that even the richer industrial nations, like Canada, will be able to *catch up* with the environment and development effects of past activities, let alone *keep up* with those of future activities. As far as poorer nations are concerned, they would stand no chance at all.

The need for a major shift to anticipate-and-prevent strategies has been recognized by many governments, by parts of certain industries, and by certain institutes and NGOs. As the material before last year's conference demonstrated, such strategies are almost invariably more effective, more economic and, in the medium to longer term, more affordable. Although some have been put in place by both government and industry, their implementation has been severely constrained by many factors, including, in my view, the constraints imposed by the institutional arrangements I have just described. No agencies – or at least very few – have been given or have assumed the mandates needed.

Improving Institutional Arrangements

Last year's conference stressed that a shift to anticipate-and-prevent strategies would require significant modifications to existing institutional arrangements. An official OECD paper said as much, stressing that the "special institutional arrangements

[required include] budget review procedures and other measures to ensure continuing interaction with central policy agencies, with treasury and finance departments, and with other ministries, especially at an early stage of policy development. The instruments require broadening the basis of policy, program and budget analysis, some better means of assessment and, perhaps more difficult, sensitive means to deal with the entrenched mindsets of venerable bureaucracies."

Environmental Investment: Changing Mindsets

A crucial feature of that mindset is how it views the relationship between the environment and the economy. Intellectual fashions often dominate events long after they have changed. The intellectual fashion that tailored most of our environmental institutions, laws, and regulations held that the investment needed to sustain the quality of the environment that was being employed by a development was essentially nonproductive. No matter whether the development was industrial, urban, transportation, agricultural, resource, or was to protect man and the environment generally, the environmental investment was seen as essentially nonproductive, or even a luxury. Certainly it had no positive economic contribution to make to the development itself. Hence the economically rational approach was to postpone such investment for as long as possible and to add it on to an activity only after the activity had given rise to specific damage to man's health and the environment; and then only if the damage had given rise to popular demand for action; and even then only if it could be demonstrated that the costs of the add-on would be greater than the future benefits generated – discounted, of course, at an appropriate rate. Past damage costs were sunk.

This intellectual fashion is seldom defended any more, at least in its raw form, and it is beginning to change. Indeed, my own observations are that the attitudes of many key people in central government agencies and corporate head offices have changed significantly on this question. They have certainly been disturbed, if not convinced, by the growing evidence, in agriculture, for example, that development without environment built-in is often nonsustainable. It is economically and ecologically nonsustainable and investment in such development can end up by reducing rather than increasing future economic potential of an industry, a sector, or a region.

Evidence of a change in intellectual fashion abounds: in Canada, for example, in the recent work by the Economic Council on regulation and in the more recent report of the Royal Commission on Canada's Economic Prospects. The commission's chapter on the environment and the economy is solid evidence of the change. In my view, it would not have been written even a few years ago; if it had, the conclusions drawn and the recommendations offered might not have been taken seriously.

OECD on Environment and Economics

This change in mindset should be facilitated by the conclusions of last year's Conference on Environment and Economics. Those conclusions clearly challenge the basis of the additionality syndrome as it had expressed itself in the early 1970s.

In those early days, you will recall, governments and their industries were very concerned about the impact that proposed environmental measures would have on economic performance. Many were convinced that they would have a seriously negative impact, especially on investment and growth, on jobs and competitivity, on trade and the balance of payments. Today, after two oil shocks, a prolonged global recession, and a recovery marked by record levels of unemployment, some still are very concerned. And during the long period of stagflation, some added a few new concerns to the list – for example, the impact of environmental measures on inflation and on technological innovation.

What did the OECD find, and what did the conference conclude?

Expenditures on environmental measures, public and private, were quite small at the beginning of the 1970s – perhaps 0.3 or 0.4 per cent of GDP. As the new programs gathered momentum, they increased gradually, depending on country, to levels of perhaps 1 to 1.5 per cent of GDP – in a few countries, 2 per cent by the end of the decade.

These expenditures had a *positive* effect on growth in the short term, as the increased demand they generated caused increases in the output of economies operating at less than full capacity. In the longer term – if one ignores the benefits of environmental action that are not reflected in the current measures of GDP and if one assumes a leveling off of environmental expenditures – the impact could become neutral or modestly negative. But this would not happen if expenditures increased – as they must, given future trends – and if our societies are to avoid a loss of past gains and further deterioration of the environmental and resource basis of future growth.

The overall impact of these expenditures on inflation has been modest – of the order of 0.1 to 0.4 percentage points annually during a period when inflation was high. The impact on the costs and prices of those industries that have incurred above-average pollution control expenditures has been higher and, in some cases, substantial. As the polluter-pays principle implies, however, the costs of environmental measures should be reflected in the costs of the industry concerned and, subsequently, depending on competitive conditions, in the prices of its products. In other words, changes in relative prices that induce reductions in the use of pollution-intensive products and processes are a good thing. They should be encouraged, not inhibited.

As regards employment, more jobs have been created by environmental measures than have been lost. Moreover, job losses have been concentrated in highly polluting industries employing old technologies and subject to normal competitive forces. The conference pointed to a number of countries where efforts have been made to prevent or minimise job losses in these industries, at the expense of environmental protection, and it underlined that such efforts were counterproductive and both economically and environmentally inefficient.

The report card on innovation was about equally positive and negative, but the conference found that regulations, economic instruments, and other measures could be designed and delivered in ways that would induce an innovative response by industry. It also found that companies like the Japanese automobile or steel companies that established research teams to develop new technologies to meet environmental standards – rather than (like their North American counterparts) legal departments to go to court or to parliament to fight them – are today in the forefront of their industry. They have benefited in terms of plant and products that are more resource-efficient, more energy-efficient, and hence, today, more economic and competitive.

The conference was able to say very little about the impact of environmental measures on trade. Few studies have been undertaken to permit even tentative conclusions to be drawn with confidence. I can tell you, however, that the commission has run into growing concern about the converse – that is, the impact of certain trade measures and balance-of-payments measures on resources and the environment.

As for trade, there is concern, for example, that a large transfer of environmental costs from industrialized to resource-based economies may be built into existing and evolving trade patterns. This could include Canada – the agricultural and forestry industries, for example – but it would apply more to those countries with no environmental regulations or with regulations that are weakly enforced. Since virtually all developing countries fall into this category, this would mean a transfer of costs from the richer to the poorer countries that can least afford them – a kind of hidden environmental subsidy of rich industrialized countries by poorer developing countries. We are looking at this, and in due course we will have something to say about it.

The balance-of-payments question is now tied into the debt crisis. I personally ran into it a few years ago in the context of OECD reviews of the environmental policies of two resource-based economies. In these cases, it had assumed basically two manifestations. First, it showed up as measures to increase exports by increasing the production of cash crops and timber. In countries with limited land resources, this can drive food production onto marginal lands and increase deforestation. Second, it showed up as measures to decrease imports, including oil imports. In some countries, this can increase pressure on biomass energy, and so further increase deforestation and land degradation.

The Environment and Economy: A Priority for Examination

As I have tried to demonstrate, the experience of the past decade is changing our view of the relationships between the environment and the economy, but a great deal of work needs to be done and can only be done by the economics profession itself.

The Economic Council of Canada has taken up some of these issues and has played – and, I hope, will continue to play – a leading role in this work.

As a country, Canada has the political conditions that could enable it to play a trailblazing role on the world stage. We have an enlightened and vigorous public opinion, a cadre of environmentally conscious leaders in government, industry, and agriculture, and, most important, a long and proud record of leadership in the international sphere. I hope that in the future we will build on this for the benefit of Canada and the wider world community.

Comments by Colin F. W. Isaacs

Come on, Canada! Let's get going with the integration of environmental considerations with our economic planning!

If one compares media reports, surveys, and polls from almost all OECD countries, one quickly comes to the conclusion that the environment ranks higher as an issue of public concern in Canada than is the case in almost any other OECD country, with the possible exception of the Scandinavian countries. Despite this, Canada has failed miserably to take hold of the opportunities that Jim MacNeill has so accurately described. I can find very little in his paper – except, perhaps, for the moderate language – with which to take issue. I will spend my few minutes highlighting just a few of my frustrations, which amplify points which Jim MacNeill has discussed.

Jim MacNeill said that environmental institutions are an "add-on." I find that is too polite a term by far. Environment Canada has generally been regarded by the rest of the federal government as some kind of social service, a nice place to spend money when times are good, the first place to make cuts when times are bad. I am not overstating the situation when I say that the Department of the Environment is regarded as a nuisance by virtually every other department, and certainly by those departments, like Agriculture, Health and Welfare, and Regional Industrial Expansion, with which contact should be the closest.

In the spring of 1984 Environment Canada asked the Niagara Institute to develop a consultation process that could achieve departmental goals through more effective consultation. Through the summer months a steering committee, comprising federal and provincial officials, business, labour, environmental groups, scientists, and others, developed a framework around the theme: "The Environment, Jobs, and the Economy: Building a Partnership." The process spawned three major workshops and four task forces. It was during one of the workshops that a senior official from the Department of Regional Industrial Expansion (DRIE) announced that it was quite inappropriate for Environment Canada to be looking at the issues of jobs and the economy, because those issues fell within his department's jurisdiction. Unfortunately, that kind of view is all too common in Ottawa. Despite DRIE'S attempt to pour cold water on the process, the final plenary agreed with the following statements, among many others:

> A watershed opportunity exists to protect and strengthen both the environment and the economy by fresh approaches based on multistakeholder consultation.
>
> The facts clearly demonstrate that cost-competitive industry and environmental protection can often be complementary if properly managed.

The Niagara Institute consultation was by no means the first occasion when I have found environmental interest groups, labour, and industry to be in almost total agreement about the interrelationship between the environment and the economy. Jim MacNeill has already spoken of the OECD Conference on Environment and Economics. A second international conference held last year was the World Industry Conference on Environment Management (WICEM), sponsored by world industry and the U.N. Environment Program in cooperation with the International Chamber of Commerce. WICEM was attended by 514 delegates from 71 countries and included representatives of industry, governments, labour, scientists, and nongovernmental organizations. Among the conclusions of the conference:

> Environmental management should be an integral part of economic development.
>
> An anticipatory and preventive approach to the threat of environmental degradation is preferable to correcting environmental problems after they have occurred.

As part of the follow-up to WICEM, UNEP has been listing the national responses to, and implementation of, WICEM's 15 specific recommendations. There have been follow-up activities in France and Brazil, in northern, central, and western Africa, in Turkey and South America, to name just a few. In Canada – nothing.

Three and a half years ago, Pollution Probe published a book entitled *Profit from Pollution Prevention*. Today, to my amazement, that book remains the most up-to-date Canadian reference for general information on clean technology. We are still selling the book at conferences across the country, which is good for our bottom line, but the fact that almost four-year-old information is still the most current reference illustrates how stagnant the interest of decision makers in clean technology has become.

About two months ago, the West German government, in conjunction with UNEP and with technical help from Glenn Munroe and Monica Campbell of Pollution Probe, held a symposium on clean technologies. Delegates from countries around the world were given a tour of some of the plants using modern clean technology today in West German industry. Needless to say, business deals will flow from contacts of that kind. Pollution Probe is delighted to have helped in this major effort to assist developing countries obtain the best available low waste technology, but I am as frustrated as hell that the economic benefits are flowing to West Germany and not to Canada.

Following the huge success of our book *Profit from Pollution Prevention* in the business community and the huge disinterest that it attracted from almost everyone in the economic planning areas of government, Pollution Probe and the Canadian Environmental Law Research Foundation (CELRF) jointly undertook a study of the legislative and economic barriers to industrial-waste reduction and recycling. The study was carried out in part under a contract with Environment Canada and delivered to them over 12 months ago. We have been amazed at the total lack of response that our federal government has seen fit to give to the report. It's not that they didn't like it – they printed hundreds of copies for free public distribution across the country – it's just that Environment Canada has no ability to influence the economic policies of government. In addition, the Waste Management Branch, under whose auspices the report was prepared, was one of the very first casualties of federal government cuts last fall.

I would like to share with you just a few of the more than 50 findings of the Pollution Probe/CELRF report. They include:

- The problem of financial support for reduction and recycling activities in the industrial sector is a barrier to its more widespread use. This is a particularly serious problem for smaller industries, which have neither the capital nor the internal research background to implement recycling or reduction equipment to modernize their factories. In addition to the lack of incentives encouraging the use of low-waste or no-waste technology, there are certain fiscal disincentives discouraging these activities in the industrial sector.

- Until recently, market conditions were based on the assumption of an abundant supply of raw resources. The excessive use of raw resources has not been discouraged. Pricing at this time may not reflect the value of raw resources in relation to their depletion rate when not reused, their scarcity, or the environmental effects of their extraction and subsequent disposal. If these costs were added to the prices of raw resources, the possibility of secondary resources becoming more competitive in the market would increase.
- There are accelerated capital cost allowance provisions (under our tax legislation) that implicitly discourage the use of recycled goods or reuse of wastes . . . because they provide positive incentives to continue using raw resources.
- Most environmental standards now set are met through traditional controls and not through preventive approaches.

I could continue with the list of conclusions and recommendations from *Breaking the Barriers*, but time suggests that I should instead urge you to buy your own copy.

As Mr. MacNeill has mentioned, the OECD Conference on Environment and Economics concluded that "continued environmental improvement and sustained economic growth are essential, compatible and interrelated policy objectives for OECD member countries."

Unfortunately, Canada has failed to respond in any meaningful way. Like Jim MacNeill, I believe that we have the political conditions that could enable us to play a trailblazing role on the world stage. However, I see already that the governments and industries of western Europe are beginning to leave us far behind. I sincerely hope that this Economic Council colloquium helps achieve the major changes in government outlook that are needed if we are to avoid, in the words of the OECD conference, "the undermining of the basis for sustained economic development."

Comments by André A. Marsan

On behalf of the Economic Council of Canada and of all the attendees here today, I would like first to express my gratitude to Dr. MacNeill for his most inspiring paper. I have read and annotated this paper over and over again and, as I did so, I discovered so much substance for thought that I wondered what commentary I could contribute further without diluting the strength of the Secretary General's message.

There is no doubt that Dr. MacNeill has touched upon the major issues that are confronting us now and that will call upon every ounce of man's capacity to innovate with respect to social structures, institutional arrangements, policies, and rules, as well as industrial-production and waste-reduction technologies needed to face up to the challenges of the new millenum.

The essence of these issues is embedded in the mandate of the World Commission on Environment and Development. It is undeniable that sustained development can only take place in an environment where the resource base is itself in a state compatible with the fulfillment of the physiological, intellectual, and spiritual needs of generations of mankind.

The instruments, mainly economic in nature, utilized so far to support decisions, big and small, did not (and still do not) have the integrative power for decision makers to assess and predict the nature and extent of every outcome. Problems are thus arising at the local, regional, and international levels as mentioned in Dr. MacNeill's paper – for example, the degradation of the resources through contamination by persistent chemicals; the degradation of the agricultural and forestry domain because of short-term economic decisions; the environmental pressure exerted on developed and Third World economies through international trade, debt financing, and large scale atmospheric transport; the transfer of environmental cost from richer to poorer countries that, according to short-sighted conventional wisdom, cannot afford environmental protection and, under export pressure, are unable to manage renewable resources according to the sustainable-yield concept; and the likely doubling of the pressure exerted on world economies and ecological capital in the next few generations.

Obviously, our societies were unable to cope effectively with the accelerated growth the world has witnessed since the Industrial Revolution; we have lived through a system of exponential growth rates of population, invention, innovation, and information. And, as Dr. MacNeill points out, mindsets, institutions, and policies have not adapted; they lag behind the scope of problems we have to solve.

We have to face very tough assessment problems related to the economics of investment in natural-resource programs. Some years ago, our firm was awarded a major socioeconomic and environmental assessment contract related to the Spruce Budworm Spraying Program. The study included an evaluation of the cost efficiency of various approaches to protecting and upgrading the forest, including the spraying of chemical and biological insecticides, and various silvicultural practices such as partial clearing, controlled fire, and reforestation through planting of trees.

While the forest-related industries constitute the most important source of income for the province of Quebec, demonstrating that silviculture is a positive economic investment was next to impossible, using classical economic analysis and a 10 per cent discount rate. This is not surprising, since silviculture practices, and especially reforestation, are rather expensive ($1,000,00/ha) and since the benefits are only to be incurred 20 to 40 years down the road. Even the protection of this investment against pest insects ($9 to $13/ha) is hardly a productive investment, since it is almost impossible to determine when and where the benefits are accrued.

Notwithstanding these economic "facts" and all the explanations by our economists, we were not satisfied because, intuitively, silviculture and reforestation do make sense. We therefore became very suspicious of the current economical analysis methodologies because the results contradicted common sense and were seen to deprive future generations of developmental assets, for short-term benefits of our own.

In discussing the matter further with our economists, we thought that there was perhaps nothing wrong with the economic analysis and discounting methods and rate. It could be that, where natural resources and the environment are concerned, the mistake lay in applying the analysis to only one sector – say, the forest sector – rather than a larger system that would encompass benefits overlooked when the sector of analysis is restricted. Also, while our economic and financial analysis using Quebec's intersectoral input-output table took into account indirect benefits such as secondary job creation, industrial output, reduction of unemployment payout, export exchange, income tax return, federal subsidies, and so on, many benefits could not be reduced to quantified entities – for instance, the effect of forest stands on soil erosion, litter build-up, oxygen generation, wildlife habitats, water temperature and turbidity, fish-spawning success, recreational amenities, health effects related to unemployment, and so on. We also thought that intergeneration equity was not taken into account, not only in terms of resource heritage, but also in terms of a wider range of options to face uncertain futures. For example, the spin-off potential that a healthy resource base offers any nation could not be quantified. We thought also that the ecological diversity provided by a well-tended forest, so widely documented by the world scientific community, could not be fitted into the economic equations.

Obviously, we have a problem here: the economists, on the one hand, telling us a "truth," and the resources scientists, on the other, telling us a different story. And the gap between the two approaches is abysmal. Given the importance of both groups for orderly development, it becomes clear that bridging this gap is now a priority at the world scale.

As Dr. MacNeill has pointed out, significant environmental success has been achieved in industrialized countries, but a tremendous challenge remains ahead of us in order to achieve a new world order based on sustainable development through environmental management truly integrated in policy, planning, and project decision making. I submit that this goal can only be met by arduously striving towards a double goal.

First, a development ethics based on intergenerational equity. Each generation should and must hold itself fully accountable for transmitting to the next an environment, a resource base, and a cultural, intellectual, scientific, and spiritual heritage that are better developed and more diversified than those which were entrusted to them. I will quote Georgescu-Roegen (1977) to make this point better: "To achieve this dream," he said, "we may begin with a minimal bioeconomic program which should take into account the fate of not only our contemporary fellow-men, but the future generations as well. Economists have preached for too long that we should maximize our present gains. It is high time that people realized that the most rational conduct is to minimize regrets."[1]

Second, the development of integrative economic-environment assessment methodologies and tools. As early as 1970, Wassily Leontieff lectured the International Symposium on Environmental Disruption in the Modern World on the possible use of the conventional input-output table to take into account environmental effects on the economies of nations.[2] Economists should perhaps pay a second look at this approach, because since the data base on environmental emissions, resources depletion, and cost of remedial measures has improved tremendously since that time. Even if the complete matrix of environmental unit "costs" is impossible to complete at this stage, the use of this approach with the help of today's computers could help in simulating economic/environmental input-output scenarios and stimulating "environmental economics" research.

Without going to such a level of sophistication, "environmental economics" studies should be pursued to establish the balance sheets of communities or regional economies where enough data exist to document environmental expenditures and economic growth patterns. The Great Lakes system might offer a good case to demonstrate that environmental investments are productive, because of the tremendous body of knowledge and expertise that accumulated there.

Also, further reflexion must be done following the thermodynamic approach to economics put forward by Georgescu-Roegen. Economists deal with the flows of money and goods; thermodynamics with the flows of energy and matter. Odum has shown how the flow of money is inversely related to the flow of energy.[3]

The functional link between economics and ecology must be found, and the thermodynamic analysis of development might afford a rich avenue. It is my conviction that a new synthesis must emerge if we are to understand the relationship between environment and development. This new scientific synthesis will emerge from team work between economists, ecologists, resource specialists, and, perhaps, thermodynamicians. I therefore suggest to the Economic Council of Canada that it promote an interdisciplinary project to contribute to the environment/development issue through innovative approaches such as those put forward by Leontieff, Georgescu-Roegen, and many others who have contributed to the field.

Floor Discussion

Question: *Institutional development is such a key issue in dealing with environmental problems that it demands further analysis. Mr. MacNeill is right to be critical of additionality, but is not add-on the only way to integration? You have to have add-on institutions in order to get existing institutions to change.*

J. MacNeill: Certainly, it was normal, given the source of the present institutions, that they should be focused on react-and-cure measures and add-on technologies. The mission that they were given was to clean up the mess. And they have done a lot of work cleaning up. Indeed, I would agree that there are a lot more future surprises in the pipeline of past maldevelopment, and the capacity of our existing institutions to react to such crises needs to be strengthened. In addition to strengthening the mandate of the existing environmental agencies, we also need to develop new approaches and perhaps new institutional forms that will enable the central economic agencies of government – the treasury boards, the energy agencies, the agricultural agencies – to take environmental considerations into account when they formulate policies in their sectors.

Question: *Past political behaviour suggests that governments must deal with an electorate that prefers short-term benefits to long-term well-being. How can the long-term environmental considerations be given more importance?*

J. MacNeill: It is very difficult. Environment policy is economic policy; it is energy policy; it is industrial policy; it is agricultural policy. The pure environmentalists have to swallow their purity and work with the people making the decisions affecting the environment, and if we do that we will find ways to make longer considerations politically relevant.

3 Fresh Water Issues

Presentation by Peter H. Pearse

Water is an integral part of the natural environment. It is also an essential input for economic production. Indeed, no other resource is such a pervasive and critical element in both the natural environment and economic activity. As a result, water management provides a sharp focus for the general policy issue of reconciling public objectives relating to economic development with those relating to environmental protection.

This paper examines the relationships between water as an input in economic production and as an environmental resource, and their implications for management policy. The discussion is confined to fresh water, on land and underground, which accounts for only a tiny fraction of natural water supply but gives rise to most management problems. And it deals with water management specifically in the Canadian context.

The paper begins, in the following section, by drawing attention to certain unique characteristics of water which bear on the design of management policy. The next part sketches the broad legal and policy framework governing water in Canada, and the evolution of attitudes and approaches to managing it. This is followed by an examination of opportunities for policy development to respond to emerging problems and needs.

Water and the Economy

It hardly needs emphasis that Canada is generously endowed with water. With more area of water than any other country, about one-quarter of the world's stock of fresh water and some 9 per cent of the total annual flow, Canadians have much more fresh surface water than almost any other nation. Moreover, though we know little about them, underground aquifers may contain several times the amount of water on the surface.

The water we use, in the sense of withdrawing it from its natural setting, amounts to a little more than 1 per cent of the average continuing flow, and the quantity we consume, in the sense that it is not returned to its natural watercourse, is about one-tenth of that.[1] Water is so abundant in Canada, relative to our demands on it, that it hardly appears to meet the criterion of scarcity which defines economic resources.

These indications of abundance are deceptive, however. One reason is that aggregate statistics for the whole country disguise regional and local exceptions. Most of Canada's great rivers flow to the Arctic sea, Hudson Bay, and northern Pacific, away from the southern concentrations of our population and industry, leaving some areas of heavy demands with scarce supplies. Another reason is that all regions are susceptible in varying degrees to flood and drought, adding a temporal dimension to scarcity. For both of these reasons, huge expenditures have been made to secure adequate water supplies for agriculture, industries, and communities. And finally, many of our most serious management problems are not related to the adequacy of flows but rather to the quality of water supplies, the disruption of natural flow regimes, and conflicts among uses and users. The degradation of water quality, especially, is concentrated in waterways near centres of population and industry, precisely where its effects are most severe. In short, water presents all the economic problems of allocating scarce resources among competing uses.

It is worth noting that the economic dimensions of water management in Canada are very substantial. The existing municipal water-supply and water-treatment infrastructure in Canada has an estimated replacement cost well in excess of $100 billion, and it requires continuing rehabilitation, upgrading, and expansion. Much more capital is directed to hydroelectric storage, agricultural irrigation, and industrial water systems. The contribution of water to the Canadian economy defies reliable quantification, but one recent study puts its value (in terms of the users' potential willingness to pay for it) in its major economic uses at between $7 and $23 billion annually.[2]

These observations point to several characteristics of water resources relevant to their management as factors of economic production. One is that water is both sedentary and fugitive; it has the features of a stock resource in some circumstances and a flow resource in others; and various uses depend differently on these characteristics. Some uses, such as navigation, depend mainly on the amount of water in lakes and channels, whereas other uses like industrial and municipal supplies, hydroelectricity, irrigation, and waste disposal depend heavily on flows. Second, water, like other natural resources, is almost always an input in production rather than a consumption good. Even water required for domestic use must be complemented with labour and capital to deliver it to where it is needed in a suitable form. Third, water has two important economic dimensions: quantity and quality. These are interdependent and, as a result, call for integrated management. Finally, the flow and quality of water are affected by all the uses made of it, and by land uses and other activities, within each basin. The natural unit for water management is thus the watershed.

Water and the Environment

Water, like forests, wildlife, and some other natural resources, has significant environmental as well as economic value, but the environmental role of water is particularly important for several reasons. One is its essential function in ecological systems. The health and productivity of other resources, such as land, fish, and forests depend critically on the water regime; in turn, the water regime is affected by the way these other resources are used. So, concern about the integrity of the natural environment often appropriately focuses on water as the sensitive element. A second reason is that it provides a wide variety of unmarketed environmental services beyond its conventional economic uses, such as transportation and recreational opportunities like boating and fishing. These benefits, though typically unpriced, are undoubtedly very substantial in Canada.

Third, water in all its various forms is a prominent feature of the Canadian landscape and is a major influence on Canadians' perception of their country. We think of Canada as land laced with great rivers, rippling streams, placid lakes, and snow-capped mountains, and we value these features. This is reflected in Canadian art, tourist brochures, and our national anthem's reference to a land "where lordly rivers flow." This value is often not articulated, but it can clearly be inferred from public expressions of concern about water. It indicates a value that is distinct from the contribution of water to ecological systems and from the services it provides; it is closer to a contribution to our national identity. Finally, water has shaped the lifestyle of many Canadians, most conspicuously that of native peoples but also, probably more than in other countries, the high proportion whose choice of work, recreation, and places to live is influenced by water and the amenities it offers. The value we derive from water resources is thus a diverse mixture of economic and environmental benefits, including a variety of direct and indirect services, public goods, externalities, and social benefits.

Basic Management Issues

The management of water flows within a watercourse involves two fundamental problems. One is that of determining the appropriate level or flow to be maintained at various points along the watercourse. This identifies the scope for withdrawals and diversions, taking account of the extent to which the water withdrawn will be returned to the waterway after being used. The other is the allocation of the available flow among users. These issues are obviously related. The economic theory underlying the efficient solution of both of them is straightforward; aggregate welfare will be increased as long as the benefits of additional use in any form exceed the costs, including the cost associated with any diminution of supplies available for other uses.

A corresponding pair of problems applies to the management of water quality. The first is the determination of the quality standard to be maintained along the watercourse. This identifies the scope for discharges of pollutants with reference to the water's assimilative capacity. The second is the allocation of the available assimilative capacity among dischargers.

In practice, these problems present formidable difficulties. As mentioned, the management of water quantity and quality are interdependent, because assimilative capacity is governed by flow, among other things. Each is subject to seasonal variation as well as geographical uniqueness. To further complicate matters, both quantity and quality can be depleted or enhanced by artificial means, creating another margin for policy adjustment. And in most cases the practical application of the theoretical criterion for optimal use is frustrated by the absence of reliable market indicators of the benefits and costs involved.

Efficiency in the use of a resource, in the broadest economic sense, refers to the extent to which it generates its potential social value. If water is to be managed efficiently, the management system must meet certain criteria. First, all potential uses and values of water must be considered without bias, including public environmental values as well as industrial, agricultural, and domestic demands. Second, the system must respond to the value of different uses at the margin, allowing marginal adjustments among uses whenever this would increase the aggregate value generated. These marginal adjustments must take account of discontinuities, irreversibilities, and uncertainties associated with certain uses to ensure that the total system is put to its highest combination of uses over time.

Third, the allocation arrangements must provide users with sufficient security in their rights of use to allow them to invest and plan their operations efficiently. Fourth, they must be flexible and responsive to changing circumstances that alter relative values over time.

Finally, the management system must be economical in its costs of organization, including not only the direct costs of public administration and enforcement, but also the costs incurred by users in gathering information, complying with regulations, and protecting themselves from dislocative official interventions. These criteria provide a framework for judging the efficacy of regulatory arrangements.

Economic efficiency is not, of course, the only goal of public policy in managing water resources. Governments have varying interests in promoting particular kinds of activities, developing certain regions, and assisting certain groups. But such distributional considerations, however worthy, do not lend themselves to a consistent frame of reference, except in defined circumstances. And in any event they do not diminish the value of a regulatory system that recognizes efficiency through the other benefits and costs of water use.

The Policy Framework

In a "perfect" market economy, wherein all costs and benefits are priced at their true social values, the sole owner of a watercourse could be expected to balance all the interdependencies and trade-offs among uses to maximize the aggregate value of his resources. In Canada, however, these circumstances do not exist. In addition to a host of market imperfections, the legal foundation provided by the constitution, common law, and legislation presents serious obstacles to coherent water management.[3]

The constitution does not mention water, but the provinces have assumed wide responsibility for managing water, along with most other natural resources under their assigned jurisdiction over "property and civil rights" and "the management and sale of public lands"; water being traditionally regarded as a form of property, and land being taken to include water. In the tradition of common law, water is not owned as such, but the provinces have largely replaced the riparian rights of common law with statutory laws that vest ownership of rights to water in the provincial crown. They assign rights to use water and to discharge wastes into watercourses under a variety of licences and permits.

This broad provincial responsibility is overlaid by the constitutional authority of the federal government for certain uses that bear significantly on water matters, such as fisheries and the protection of fish habitat, navigation, federal lands, and relations with foreign governments. More general powers over "works for the general advantage of Canada," "peace, order, and good government," and criminal law may also limit provincial authority in managing water resources. This results in an exceedingly complicated legal and policy framework for water management in Canada.

These arrangements fall short of the coherence that economic and environmental considerations suggest is needed for effective water management in Canada. Some of the most fundamental shortcomings can be summarized as follows:

1. Ownership of the resource, which economic theory suggests is necessary for efficient allocation of all factors of production through market processes, does not exist. Moreover, by economic criteria, the rights to use water, both for withdrawal uses and for waste disposal, are seriously flawed with respect to their security, transferability, precedence, and other terms and conditions. This impedes the efficient market allocation of the resource.

2. While some uses of water are provided for through licences and permits, others are not. Typically excluded are domestic uses, almost all in-stream uses like navigation and recreation, fisheries and wildlife protection, and other environmental and conservation purposes. This bias distorts the allocation of water among uses and users.

3. The value of water, and the rights to use water, are rarely reflected in market prices; they are not usually transferable among uses, and priorities are administered in a more-or-less arbitrary fashion. This puts a heavy onus on governmental regulation.

4. Interdependent uses are regulated under separate legal and administrative arrangements. Authority over major uses is divided by the constitution between the federal and provincial governments. Both levels have responsibilities relating to both flows and quality, and administer them under separate regulatory systems. Each has adopted a variety of special legal and administrative arrangements to regulate particular uses. This plethora of regulatory arrangements (for purposes ranging from federal fish habitat protection and navigation to provincial regulation of withdrawals, waste disposal, and hydroelectric and agricultural uses) is not coherent or well coordinated.

5. Few provisions are made to systematically plan and integrate the interdependent uses of water within watersheds. Many major watersheds and river basins are cut by boundaries between provinces and territories and by the border with the United States, and arrangements for cooperative management in these cases are meagre. Moreover, only a few provinces have provisions for the coherent management of watersheds within their boundaries. Thus the institutional arrangements needed to systematically take account of the impacts of each use on the others is often lacking.

6. A good deal of uncertainty surrounds the constitutional and legal basis for managing some important water uses, such as those that interrupt or pollute rivers crossing provincial boundaries and activities that impinge on fish habitat. This uncertainty is an impediment to orderly development of water resources.

Development of Water Policy

The evolution of water policy in Canada reveals a progressive broadening of approaches to water management. Early attention focused on navigation, because of the strategic importance of St. Lawrence waterways and the need to transport timber and facilitate other commerce. This stimulated significant public and private development of canals and other works around the middle of the 19th century. Over the subsequent decades, the federal and provincial governments developed legislation and administrative structures to manage water for purposes of fisheries, agriculture, industry, municipal supplies, and hydroelectric generation. Water policy thus developed; but it was not a policy for managing water *per se*, so much as a collection of disparate programs for developing water as an adjunct to particular economic activities, administered under a variety of legislation by specialized agencies. Correspondingly, the early cooperative undertakings with the United States dealt with water works for navigation, hydroelectricity, and irrigation.

After World War II, water resources continued to be viewed as means of nation-building, and projects, often of a huge scale, were undertaken to develop hydroelectric power, agriculture, and seaway transportation. But, in response to growing pressures and conflicts in some waterways, attention began to be directed to the need for coordination in resource development. The federal and provincial governments thus established joint arrangements for managing forests on the eastern slopes of the Rockies to sustain runoff in the Saskatchewan River; an intergovernmental board was created to allocate water in rivers flowing across the Prairie provinces; and coordinating legislation was passed to facilitate studies of rivers like the Fraser. Other arrangements were made to enable cooperative development of major projects and integration of water developments within regional economic plans. The concepts of coordinated development and multiple use thus began to bear on water resource development, but they were viewed mainly as constraints on single-purpose economic uses of water.

The mid-1960s ushered in a new and broadly based concern for the environment generally, and this had a profound impact on approaches to water management. Nearly all governments created a Department of the Environment and assigned it responsibility for controlling water pollution, among other things. Water began to be considered not just a means of promoting development of other activities but as an essential component of the environment, demanding management in its own right.

This new recognition of water as a resource demanding specific policy attention was reflected in several major developments in the 1970s. One was new federal legislation directed specifically towards improved water management and use, most significantly the Canada Water Act and the Northern Inland Waters Act, both passed in 1970. New legislation and regulatory arrangements were also adopted by provinces. Saskatchewan was particularly innovative in creating a crown corporation to administer and develop water resources.

A second thrust was towards protection of the natural quality of water systems from pollution. In 1970 the federal government passed the Arctic Waters Pollution Prevention Act and strengthened the pollution control provisions of the Canada Shipping Act and the Fisheries Act. The Environmental Contaminants Act was adopted in 1975. This was paralleled by a shift in the emphasis of cooperative arrangements with the United States from development projects to the resolution of environmental problems, especially relating to the Great Lakes.

A third development involved increased efforts towards federal-provincial intergovernmental cooperation in a wide range of water programs, including the collection of hydrological data, the design of quality objectives for water uses, flood control, sewage treatment works, and pollution control administration.

Finally, recent years have witnessed growing recognition of the need for the integrated management of watersheds. Intergovernmental arrangements have been made for river basin studies and planning on major rivers in Canada, such as the Yukon, Mackenzie, and Saint John, and on international waterways, such as the Great Lakes. Several provinces, following Ontario's early experiment with conservation authorities, have introduced arrangements for managing watersheds on a coherent basis, often with organized public participation and advice.

These new efforts imply a recognition that, in order to sustain the environmental and economic benefits derived from water, these resources must be developed and used with more attention to the natural character of hydrologic regimes, their interdependence with other elements of the environment, and the interdependence of their uses. Notwithstanding the abundance of water resources in Canada, they need comprehensive, scientific management and careful regulation of their use.

New Perceptions

Two other important changes in the public perception of water policy needs appear to be emerging. One contrasts directly with our traditional reliance on developing increased supplies to meet the growing demands of industry, agriculture, and communities. Many interest groups have begun to advocate a shift from this so-called "supply management" to "demand management," which implies measures to constrain the growth of water use through conservation measures, including pricing. Experience in Canada and elsewhere suggests almost limitless opportunities to use water more efficiently, especially in Canada, where per capita use is close to the highest in the world. These range from recycling systems in industrial plants and improved agricultural irrigation techniques to water-efficient plumbing in residential housing. Probably the most effective policy is the pricing of water and the use of wastewater systems.

Appropriate pricing and other conservation measures are increasingly being recognized as means of advancing both economic and environmental objectives. The resulting increased efficiency in water use reduces the growing cost of water supply systems as they are extended to tap less accessible sources, and of waste treatment systems that must be expanded to accommodate the increased throughput. At the same time, lower demands reduce environmental pressures that result from the diversions, storage, and other works typically associated with increasing supplies. Additional benefits from pricing water are seen in generating revenues to cover the cost of the needed infrastructure and in allocating these costs equitably among users. Although water pricing systems remain rudimentary in Canada, increasing support for them is found among broadly based consumer groups and labour organizations as well as environmental organizations.[4] To some extent, at least, this new interest in demand management coalesces economic and environmental objectives.

The other changing perception relates to the relationship between environmental protection and economic development. As wide-ranging controls on pollution and other forms of environmental disruption were introduced during the last couple of decades, they were typically regarded as constraints on economic growth. Pollution was considered an inevitable consequence of industrial expansion, and strict controls imposed costs that threatened jobs and international competitiveness.

Increasingly, however, a healthy environment is seen to complement economic performance. Undoubtedly, environmental controls increase production costs, but the choice is not simply between a cleaner environment and higher production. Environmental protection helps to ensure the continuing productivity of land, forests, and water. Destruction of a fishery by pollution or of a forest by acid rain affects income and employment in the same way as the closing of a mine or a factory. Thus the perception that the environment has to be protected against the onslaught of economic activity is giving way to the view that it must be managed and conserved to secure continuing economic prosperity. In these oversimplified terms, the environmental movement appears to have come full circle, converging with the conservation movement of the late 19th and early 20th centuries, which was concerned with the protection of natural resources for the economic benefit of future generations.[5]

This new view has been expressed most strongly by the recent report of the Macdonald Commission, which denied the existence of any conflict between economic growth and environmental quality in the long term, or of any trade-off between them.[6] According to empirical studies by the OECD, this is an exaggeration, but the interdependence of productive environments and economies is inescapable, especially in a resource-based economy like Canada's. The scale of modern environmental disruptions, and the destruction that can result from new threats like atmospheric pollution and toxic chemicals, have focused attention on these essential links between the health of the environment and the productivity of the economy.

Opportunities for Policy Development

Appropriate policy for managing water resources must be designed and evaluated with reference to public objectives. As already suggested, these are varied, including considerations of economic and regional development, income distribution, protection of culture and lifestyles, and the integrity of the natural environment. The relevance of these and other goals, and their relative importance, vary with time and place, and they often conflict.

However, it can reasonably be inferred that today, Canadian governments generally seek to take advantage of the potential economic benefits of water resources while at the same time preserving the health of the natural environment. Notwithstanding the inevitability of compromises in these goals, they are undoubtedly jointly feasible. Even reductions in our use of water, where and when that might be necessary to protect the environment, would not preclude further economic growth. The task is to design management systems that will produce the right balance of uses and environmental values in widely varying circumstances.

In view of the constitutional division of responsibilities for water management and of the entrenched systems of laws and rights to resources, simple market solutions to the management of water will not suffice. Although there is undoubtedly scope for improvement through more attention to economic incentives to achieve management objectives, there remains a heavy onus on governmental intervention and regulation. Moreover, throughout Canada more than one government is involved; federal, provincial, and territorial responsibilities intersect and overlap, as do Canadian and U.S. responsibilities on major waterways. This divided authority, aggravated by fragmented legal and administrative arrangements within governments, presents a major obstacle to comprehensive water management.

Nevertheless, there are many opportunities for improving the policy and institutional framework for managing water resources. The remainder of this paper examines some of the most promising of these.

Watershed Management

The recent recognition of the watershed, or drainage basin, as the appropriate geographical unit for water management has already been noted. Management systems that encompass the full scope of hydrological systems within a watershed, and all the interdependent uses of water within it, facilitate a comprehensive accounting of the full costs and benefits of alternative patterns of water development. They also provide opportunities for local participation in resource management decisions. As pressures on water systems grow, recognition of the interactions among uses and values within a comprehensive watershed management framework becomes increasingly important.

Experience with comprehensive watershed planning and management systems in Canada, as in the United States, has been mixed. In Canada, a number of river basin studies and planning projects were undertaken under federal-provincial cost-sharing agreements in the 1960s and 1970s, but few led to implementation agreements, and no new intergovernmental investigations have been negotiated since 1981. In the United States, several federal-state commissions were established in the 1960s to design comprehensive master plans for developing major river basins, but their achievements were modest and they were abolished in 1981. In retrospect, these attempts at comprehensive, interjurisdictional planning were too unwieldy; they conflicted with established regulatory structures; and they were not sufficiently flexible.

More modest efforts have proven more successful. Ontario, Alberta, Saskatchewan, and Manitoba have adopted management or planning systems for certain watersheds, usually with provisions for local participation and advice. Other countries, including Australia, Britain, and some European countries, have established more elaborate river basin authorities with regulatory powers and independent sources of revenue.[7]

Notwithstanding the formidable practical difficulties associated with implementing the concept, integrated watershed management seems essential for effective resource management in the face of growing pressures. This implies the specification of objectives for flows and water quality to guide the allocation of rights to withdraw water and discharge wastes, sufficient information about hydrology and uses to enable assessments of the full range of impacts of potential developments, and participation or cooperation of all relevant regulatory agencies. New computer-based techniques for modeling complex systems are well suited to the need for a common frame of reference for managing river systems.

Most Canadian rivers do not warrant elaborate arrangements of this kind, so attention can be focused on the critical water systems. Various degrees of formality and authority of the watershed organization are possible, ranging from ad hoc consultative arrangements to river basin boards with regulatory powers. Arrangements for public participation can also be adapted to suit individual circumstances. Probably the major difficulty is in eliciting the cooperation of all governments and agencies involved. On this matter, Canadian experience with federal-provincial agreements and delegation of administrative responsibilities might be built upon.

Systematic Evaluation

Although much of the theory of benefit-cost analysis was developed in the context of water projects, water resource development in Canada has not been guided consistently, or even usually, by systematic evaluation of investments and alternatives. Huge projects for irrigation, hydroelectricity, and navigation have been undertaken without rigorous and explicit assessments of their economic and environmental implications.

Many of these have become highly controversial, but informed debate has been impeded by vague and confused information. The federal Treasury Board's standard procedures for assessing projects are adopted for some projects (like fish enhancement on the Pacific coast) but apparently ignored where programs (such as agricultural irrigation) would not meet the investment criteria.[8] Provincial assessment procedures are correspondingly undeveloped. No government has put much effort into developing a coherent and consistent framework for assessing water resource developments, despite the magnitude of public expenditures in this area and the well-developed techniques now available. Probably equally important is the lack of clear criteria for numerous small-scale decisions about water uses and compromises among demands. Clearly, if officials and agencies are expected to manage water for its highest combination of uses, they must be given explicit objectives and criteria for achieving this.

This lack of guidance for advancing the broad public interest in water use is aggravated by certain formal obstacles to the systematic, unbiased consideration of alternatives. The fragmentation of authority among governments, departments, and agencies, noted earlier, results in differences in information, interest, power, and influence among water uses and users. Some legislation, such as the powerful federal Fisheries Act, does not permit officials to engage in compromises among uses of water,[9] and provincial water rights legislation typically specifies priorities among uses.[10] The removal of these institutional obstacles seems to be an obvious first step in improving water management.

The need for systematic assessments extends well beyond the benefits and costs of particular patterns of water use to more fundamental policy choices. For example, the implications of measures to constrain demand must be weighed against the alternative of increasing supplies, measures to abate pollution against increased purification effort, and so on. Attention needs to be focused on the full range of alternatives to achieving management objectives.

Assessments of water management call for special attention to two needs. One is the assessment of risk and uncertainty. This is particularly important in circumstances where irreversible changes to natural resources are contemplated through major diversions, inter-basin transfers, contamination by persistent substances, and so on. The long-term effects of such changes, individually and collectively, are highly uncertain. The goal of maintaining the essential health of the environment, mentioned earlier, implies a need to explicitly recognize as a cost the risk of impairing it.

The other special need is for appropriate mechanisms for channeling public participation in major decisions. The remarkable number and variety of special-interest groups concerned with water management in Canada, including many whose interest focuses on particular waterways, provides evidence of a perceived need to ensure that governmental decision making will be supplemented with direct public input.

The special demand for participatory arrangements in water management is undoubtedly grounded mainly in concerns about the environment. Since these concerns must be dealt with more or less subjectively, it becomes important to channel them in a systematic way into the decision-making process. Since the 1960s there has been a profusion of participatory arrangements, ranging from informal consultations to public hearings and advisory bodies. Their success has been mixed, judging from the range of enthusiasm and frustration experienced by both public participants and governmental officials, but the essential elements for success have been identified.[11]

Pricing

Almost everywhere in Canada, water, and its waste assimilative capacity, are provided to users at nominal or zero cost. Pricing systems, to the extent that they exist, are rudimentary, involving fixed charges, rentals, and declining block rates, but rarely with reference to all costs or to the value of the water used.

This policy is now being questioned, and support for pricing water is growing for several reasons. First, a price on water creates an incentive to use water efficiently, contributing to conservation and reducing environmental pressures. Second, by reducing the quantity of water used and the waste-disposal capacity needed, pricing reduces infrastructure costs. Third, a price helps to identify the users who can make the most beneficial use of the water available, thus assisting with the allocation problem. Fourth, pricing generates revenue that may be required to develop water supply and disposal systems, and it ensures that the costs are equitably borne by the beneficiaries.

The interest of economists in the efficient use of water, capital, and other resources, and the interest of environmentalists in conservation, converge in the issue of pricing. Moreover, there is now extensive evidence in Canada, the United States, and elsewhere that water pricing influences its use significantly and thereby affords a powerful instrument for demand management.[12] The present rudimentary systems of water charges in Canada leave a great deal of promising scope for improved water management through pricing. The difficulties lie in designing appropriate price schedules and in enabling users to make substantial adjustments to them from the prevailing arrangements.

Support for pricing water and waste discharges undoubtedly rests in part on the political appeal of propositions like "user-pay" and "polluter-pay."[13] This reflects a somewhat naïve conception of the impact of pricing, because as long as producers operate in competitive markets they must, in the long run, pass the cost on to consumers or shift it back to the owners of the factors of production. The result will depend on the circumstances of each case, and little more of a general nature can be said about it. The important point is that the benefits of pricing water derive not from its distributional impact (there is a rich variety of other fiscal measures available to reallocate financial burdens) but rather from its effects on behaviour, through incentives to use resources more efficiently.

Property Rights

Like pricing, the form of rights used to provide access to the resource offers fertile ground for improvement in the framework of policy for managing water in Canada. In contrast to the emphasis given by U.S. economists to pricing as a means of improving efficiency, many Canadian investigators have emphasized the potential of well-designed property rights as instruments for regulating the use not only of water but of other common property resources as well.[14]

These studies lead to the conclusion that once objectives for the quantity and quality of water in a watercourse are determined, suitably designed quantitative rights to the available flows and assimilative capacity allocated among users will stimulate efficient resource use through economic incentives with minimal additional intervention. At present, this approach is not well developed as a means of water quality control in Canada, but many examples can be found in licensing arrangements for regulating water withdrawals and, indeed, for regulating the use of many other natural resources like timber, rangeland, and fish.[15]

The rights to use water or to discharge wastes can be expected to assume a value reflecting the scarcity of the resource relative to the demands on it. As long as the rights are divisable and transferable, the method of initial allocation would be of no lasting significance, since they would be reallocated through the market among those who could make the highest use of them. Their value would provide the desired financial incentive to economize on the use of water and induce users to achieve the socially desired degree of conservation and pollution abatement.

This approach to regulating water use has several unique features.[16] First, it requires minimal resource information; the regulatory agency can adjust the allocated flows and discharges by issuing additional rights or purchasing them, without involuntary infringements on acquired privileges. Second, it is relatively simple to administer. In contrast to a dependence on pricing to induce efficient resource use, which requires the regulatory agency to be continuously involved in adjusting rates that must differ widely among watercourses and over time as conditions change, the market in rights can be left to respond to varying costs and values.

Third, the property rights approach lends itself to crown appropriation of any desired share of the value of the resources used, through application of user fees or initial charges for rights. The value of licences would be reduced concomitantly, but this would not interfere with the market forces promoting efficient use. Fourth, the rights issued can provide security and certainty to users, because they can be issued with long terms while preserving needed flexibility. Finally, rights with appropriate features not only enable effective regulation with relatively low administrative burden, but they also lend themselves to easy adaptation from existing forms of licences and permits.

Suitably designed rights to use water and to discharge wastes thus help to overcome some of the market failures that currently impede efficient water use, noted earlier. Many complications remain, leaving scope for regulatory intervention. But regulatory agencies can concentrate on the objectives for the watercourse, and the allowable withdrawals and discharges into it. This approach thus complements watershed-based management and facilitates constructive public participation as well.

Collective Works

We have a good deal of experience with municipal water-supply and waste-treatment systems in Canada. These works are justified on grounds that it is often much less costly to build collective works than for each user to provide separate supply and waste-treatment facilities.

However, unless collective systems are supplemented with pricing or other controls, they leave many of the causes of wasteful use mentioned earlier. Individual users will lack incentives to constrain their use of water, resulting in excessive demands and high infrastructure costs. Moreover, it is not always more efficient to restore water quality than it is to abate pollution at the source, especially at industrial sources. And as long as the cost of collective works is broadly shared by taxpayers, the full social costs of goods and services will not be reflected in their prices, and so production and consumption will be distorted. These problems underlie the need to buttress collective water-supply and waste-treatment systems with user charges.

Subsidies

Both the federal government and the provinces in Canada have provided substantial financial assistance to municipalities and industries to augment water supplies and abate pollution. These programs have enabled the public at large to share the cost of improving water supplies and protecting the environment.

Subsidies, as they have typically been provided in Canada, create a variety of distortions in water use. In the first place, the subsidy is rarely recouped from the beneficiaries, so that the cost of water or waste treatment is simply lowered, aggravating incentives for excessive demands. In the second place, they are usually offered more or less undiscriminatingly to municipalities or to firms in particular industrial sectors, without respect to the differing costs and benefits among watersheds and users. Finally, they have typically provided assistance for capital expenditures only, creating a bias toward capital-intensive facilities. Political and administrative considerations make it extremely difficult to design subsidy programs that are sufficiently discriminating to overcome these problems.

Equipment Standards

Many provincial regulatory agencies require industrial water users and waste dischargers to adopt prescribed equipment in their production processes, sometimes referred to as the "best available technology." In terms of promoting the efficient use of water and protecting the environment, these regulations have obvious deficiencies.

Equipment requirements provide no incentives for conserving water or abating pollution other than to adopt the mandatory technology. Moreover, they eliminate incentives to seek out even the most efficient means of achieving the desired standard of performance. In addition, if one discharger on a watercourse could constrain his demands for water or abate his pollution at lower cost than another, there is no means of taking advantage of this reallocation.

Most seriously, however, prescriptions of equipment and processes fail to recognize differences in the capacity of different watercourses and the pressures on them. They thus force water users to uniformly invest in prescribed facilities regardless of either economic or environmental considerations.

Performance Standards

Reference has already been made to the need to determine objectives for watercourses, relating to the desired levels, flows, and quality. These are environmental standards, or "ambient standards" in the case of water quality. In Canada, such standards are determined variously in terms of chemical concentrations, toxicity to fish, turbidity, and so on. National guidelines for the quality of water for particular uses of water, such as drinking and swimming, have been agreed upon by federal and provincial agencies. These guidelines and standards provide a basic datum for allocating withdrawals and waste discharges.

In addition, federal and provincial governments specify standards of quality for the effluents of individual dischargers under pollution control regulations. These are in the form of maximum acceptable concentrations of contaminants in wastewater discharged into waterways.

Discharge standards suffer from many of the same deficiencies as equipment standards, although they have the advantage of allowing dischargers to seek out the least-cost method of abatement. They provide no incentives to abate pollution beyond the allowed concentrations; they do not enable efficient reallocations, among users of their use, of the assimilative capacities of watercourses; and they take no account of varying abatement costs and benefits. Moreover, they do not recognize the varying assimilative capacities of different watercourses. As a result, such uniform standards leave some waters polluted and others underutilized, with consequent wasteful use of both water and abatement resources.

Discharge standards nevertheless provide relatively simple and uncontroversial means of achieving minimal standards of performance in pollution control. Indeed, there is no ready alternative to controlling toxic and persistent substances that cannot be assimilated and pose such environmental threats that the objective must be to eliminate them altogether. In other cases, however, they provide only a minimum baseline beyond which effective pollution control calls for mesures that recognize the capacity of individual watercourses.

Governmental Entrepreneurship

A review of regulatory methods would not be complete without consideration of governmental corporations that might be given authority to manage and develop water resources, along the lines of the recently created Saskatchewan Water Corporation.

Theoretically, at least, such a single enterprise could overcome many of the existing obstacles to effective water management. With appropriate terms of reference and sufficient powers, it could design objectives for flows and quality in light of the circumstances of each watershed, invoke pricing and other means to encourage efficient use, invest in works to enhance the value of resources, and internalize some of the fragmented benefits and costs. In effect, it could create an entrepreneurial landlord that could maximize the value of the resources under its control.

Many problems would remain, however. A provincial crown corporation could not internalize the interests and powers of the federal government or of other jurisdictions that share waterways, at least without unprecedented delegation of powers. Moreover, it could hardly assume the authority of all other provincial agencies as they bear on water management. Thus the fragmentation of responsibilities and the task for coordination would persist. Moreover, the need for systems of pricing and user rights would remain and would simply be transferred from one agency to another.

The advantages of a crown corporation appear to lie mainly in improving the allocation and use of water in economic activities. The benefits in providing for environmental values are less clear.

Provincial corporations raise again the question of the appropriate geographical scope of water management. If the natural management unit is the watershed, individual river basin authorities, rather than authorities whose scope is based on political boundaries, may be at least equally well suited to assume water management responsibilities.

Conclusion

Water policy in Canada has evolved irregularly over the past century within the federal and provincial governments. Today, there exists an unprecedented concern that this evolution has not kept pace with emerging pressures and public aspirations. The dispersion of responsibilities and perceptions of resource abundance have resulted in a loose and incoherent policy framework that may not be sufficiently robust to cope with the modern needs for both economic development and environmental protection.

The Government of Canada is now reassessing its water policy, in the wake of a recent public inquiry on the subject.[17] In response to the inquiry's findings and recommendations, the federal Minister of the Environment has expressed determination to improve the framework for water management and pollution control. However, many of the needed reforms will depend upon the cooperation of provincial and territorial governments.

This paper has attempted to identify the major obstacles to efficient water management in Canada and the opportunities for improvement. It leads to the conclusion that there is wide scope for policy reform. Moreover, significant improvements appear to be possible with modest political and administrative effort.

Comments by Andrew L. Hamilton (abridged)

I am very pleased with this opportunity to try to challenge and provoke you to rethink some of the more fundamental aspects of the way we manage our uses and abuses of freshwater ecosystems. I also take it as a sign that more and more people are coming to recognize that sustainable development and sustainable economics can only be built on a foundation of sustainable ecosystems. Water is an essential component of these systems.

The reflections that I wish to leave with you were stimulated in part by Dr. Pearse's paper and in part by the much more comprehensive final report of the Inquiry on Federal Water Policy, which was chaired by Dr. Pearse. For those of you who haven't seen this report, I would urge you to obtain a copy. It is very readable, and it provides an excellent overall assessment of freshwater issues in the Canadian context. In my view, it also provides a knowledgeable analysis of the strengths and weaknesses of present policies and programs.

I am less enthusiastic about the solutions that are offered in the report, because I see them as being too conservative to lead to important, fundamental changes in the way we address water issues. While I realize that many small "add-on" changes can have a cumulative effect that may be important, it seems to me that the proposed recommendations reflect a general willingness to accept current dogma, current trends, and current directions and most of the recommendations seem designed to reinforce and strengthen the present way of doing business. In short, while the report, which is entitled *Currents of Change*, does hint at the need for change, it is hardly a blueprint for change, and I'm not sure that the authors believe that a mandate for change is needed. In this sense, I am a bit disappointed in the final report because I think the authors did have a mandate to be bolder.

I also believe that more fundamental changes are needed. We must fundamentally alter the way we relate to the rest of the ecosystem and the way we value the long-term quality, productive capacity, and utility of our land, air, water, and living resources. Environmental research is a crucial element in this, but it must be supported by firm and appropriate actions.

Perhaps my biggest disagreement with the final report of the Inquiry on Federal Water Policy is that the authors do not challenge the philosophical underpinning of the traditional view of water management. Perhaps in a bygone era this view of water management had merit in the context of managing water and the dams, diversions, drainage ditches, and irrigation channels that we used to manage the supply of water. Now, however, the important water issues are much more complex. A few of the central features are as follows:

Water is a strategic issue — Water has played a central role in the history of our nation. In future, the long-term conservation, protection, and wise use of water will be fundamental if we are to have a sustainable and secure society. Technological advances, clever tax schemes, patchwork legislation, and pricing systems that reflect a more appropriate value for water can all make a contribution. However, unless our attitudes, behaviour, and institutional mechanisms consistently reflect the long-term, strategic importance of water, both as a resource and as an essential component of the biosphere, it seems to me that we are likely to see a continuing erosion in the health and utility of freshwater systems.

Water is a horizontal issue — Constitutions, legislative mandates, and the bureaucratic compartmentalization of water issues were not designed with a view to managing many of the major issues of the day. Intergovernmental, interdepartmental, and interservice wrangling and fence-building have reinforced a piecemeal approach to water issues, and somehow or other we must develop better ways of taking a more integrated approach despite the constraints. Departments like Environment Canada and agencies like the

Economic Council of Canada have a responsibility to recognize and encourage attitudes, behaviour, and institutional mechanisms that reflect horizontal aspects of freshwater issues. Unless there are effective mechanisms for influencing policy and program decisions that impinge on the quality and quantity of the freshwater resource, we cannot expect to do a very good job of looking after the freshwater component of our environment.

Water is a cross-media issue — No longer is it adequate to think of water as being a discrete surface resource. Underground and atmospheric resources and pathways are clearly significant and merely illustrate the extent of the linkages between air, land, and water. Water quality, in particular, is intimately linked to land-use practices and policies. In short, we simply cannot manage water issues without influencing the policies, programs, and activities of groups and individuals that often tend to see water as a free commodity or, even worse, as something that is of no concern to them.

Water is everyone's business — Decisions and actions affecting water and the uses made of water occur at all levels of government and in all sectors of society. Water issues are incredibly complex, and the policies, programs, and actions that impinge on water will inevitably lead to allocative conflicts over the rights to use and abuse water. Keeping these conflicts at manageable levels requires understanding and a shared sense of responsibility – ingredients that are often lacking.

I suggest that, with minor exceptions, we are a long way from having the sort of institutional arrangements that are likely to lead to a long-term ecosystem perspective with respect to managing water issues. The challenge is no longer simply to manage water. The real challenge is to manage human activities in a manner that is consistent with maintaining the health and integrity of the ecosystem for ourselves, our neighbours, and our descendants.

If one is serious about trying to understand the root causes of the rise and decline of the freshwater sciences in Canada, one can learn a lot from reviewing the history of freshwater research within Environment Canada and Fisheries and Oceans Canada. The two research "flagships" are the Canada Centre for Inland Waters (CCIW) in Burlington, Ontario, and the Freshwater Institute (FWI) in Winnipeg, Manitoba. Both of these centres originated in the late 1960s in response to increased general awareness of the environment and to concerns over pollution in the lower Great Lakes, which were focused through a reference to the International Joint Commission. Both institutes were created with national mandates and much optimism. They soon attracted world-class scientists and quickly established Canada as a world leader in the field.

Things have changed dramatically. The Fisheries Research Board of Canada, creator of FWI, subsequently lost its status as a separate employer, and the Freshwater Institute went from being an institute with a national mandate for freshwater research to becoming a building in which the research function was integrated with the regional fisheries management function. In effect, this meant that the Institute now had to rationalize and defend its programs not on the basis of national needs but on the basis of operationally defined roles that could be related to the federal government's responsibilities under the Fisheries Act. Understandably, the fact that the administration of the Fisheries Act in the Prairie provinces and Ontario had been delegated to the provinces created a rather insecure climate for research.

The situation is not very different at the Canada Centre for Inland Waters. Environment Canada's major research group at the Centre is the National Water Research Institute (NWRI), which is a part of the Inland Waters Directorate. Despite the presence of a major international agreement (the Great Lakes Water Quality Agreement of 1978) that emphasizes an ecosystem approach, the researchers in this institute have been under increasing pressure to do client-oriented, water management research in direct support of the directorate's water management responsibilities. Ability to address the biological dimensions of freshwater issues is weak at the NWRI, as is expertise in the social sciences.

These organizational arrangements have affected research morale and productivity. Many scientists at these institutes find that their work is being increasingly controlled by others and channeled in accordance with short-term bureaucratic pressures that have little to do with long-term relevance. They must try to defend their work on the basis of the narrowly defined mandates of their service or directorate. Similarly, the need for excellence is not appreciated. All too frequently, as people have received international recognition for world-class research, it is interpreted as a case of overkill, and the area of work is then deemed to no longer be a priority. Many of them sense a lack of direction while at the same time complaining of what amounts to nit-picking, micro management.

In a very real sense, Canada's two major freshwater research institutes are little more than pawns in the larger science-policy debates carried on at senior levels of government. For those of you who wish to delve deeper into these aspects, I would strongly recommend that you read F. R. Hayes' book *The Chaining of Prometheus: Evolution of a Power Structure for Canadian Science*.[18] J. R. Vallentyne's review of the climate for freshwater research is another perceptive analysis, and his challenge for "facing the long term" is as valid today as it was at the time of writing in 1978.[19] L. C. Newman's 1979 review of the environment for research in the Environmental Management Service (which included the National Water Research Institute) is another perceptive analysis.[20]

The emphasis on linking freshwater sciences directly to perceived operational responsibilities of the line departments can be attributed partly to the influence of science policy ideas held within central agencies of the federal government. Their thinking is revealed in a statement made in the late 1960s by the secretary of the Treasury Board to the Senate Science Committee. In summary he said:

> I would like to say a few words about science. In the eyes of the Board, science is not regarded as a thing in itself but as a means to an end. Scientific projects are not examined on their merits but as components of programs. Several agencies, including the National Research Council, carry on projects in science in order to further their defined program objectives. These mission-oriented departments have to be viewed within the framework of the programs that they have been allocated. This kind of thinking has enabled the Treasury Board to identify selected areas of research and development that justified priority treatment.
>
> Decision making will be strengthened through planning, programming and budgeting. There are three key aspects to PPB. The first is to have clear objectives derived from national goals. The second adds the dimension of cost-benefit analysis, and the third is the need to examine alternative means. PPB should enable parliamentarians to compare expenditure proposals with objectives.

In essence, he was saying that Treasury Board took the position that science activities must be justified on the basis of legislative mandates and departmental programs and not on the basis of their merits. It also meant that planning, programming, and budgeting (PPB) would apply to science activities just as it applied to any other government program. Today, the acronyms are different, but not much else seems to have changed.

Another very important science policy has been the federal government's "make or buy" policy. As this policy was implemented, it effectively moved resources from in-house federal research programs to the private sector via the Department of Supply and Services. In the process, a significant environmental consulting sector, largely dependent on government funds, has evolved. This sector has been able to reorganize and repackage data and sell the resulting synthesis as proprietory information and advice to government departments. But it has not contributed very much to the stock of knowledge on freshwater ecosystems. Another outcome of this diversion of resources from the in-house research programs is that institutes like the FWI and the NWRI have not been able to recruit new scientific personnel, and as a result they now have almost no scientists under 40 years of age.

The final report of the Inquiry on Federal Water Policy reflects an awareness of the need for a comprehensive and current knowledge base on water and water related issues. Some of the recommendations could help to deal with some aspects of the problem, although in a rather indirect manner. They would have a Canadian Water Resources Research Council to advise the Minister of the Environment and the Research Advisory Boards that would review programs and advise the minister. These agencies would ensure a broad cross-section of advice. They would also provide a mechanism that might help good research ideas filter to the top and become departmental policy. At the same time, both suggestions don't really change the top-down operational control of the research function.

Similarly, although the Inquiry recommendation to raise the Inland Waters Directorate to the status of a Water Service might give a higher profile to water issues, it does not change the way research is managed nor does it build bridges between the water sector and other components of the bureaucracy. Likewise, I cannot see how a strengthened interdepartmental committee on water would lead to better coordination and integration of water initiatives.

The reason, quite frankly, is that the big water issues cannot be coordinated from the top-down, and no department is going to willingly give up power in areas where it has legislative or program responsibilities. Real integration, coordination, and leadership on water issues and other major environmental issues are not likely to happen in the absence of an institutional framework that encourages interagency and interdepartmental cooperation at the basic fact-finding level. Consensus building won't happen without mechanisms to encourage joint fact-finding and joint research programs. As of now, few of these mechanisms exist, and those that do tend to be unduly encumbered in bureaucratic red tape.

Within the existing constitutional and legislative framework it seems clear that Canadians must be able to count on the federal government playing a significant watchdog role on environmental issues. Developing a sense of stewardship towards the environment is also a national responsibility so as to ensure that the rights and opportunities of future generations of Canadians are given fair treatment. And, it seems to me that the federal institution with the best opportunity to provide leadership in this important area is Environment Canada.

If Environment Canada is to enhance its ability to have "horizontal" influence within Canada, there are two fundamentally different strategies that the department could follow. One is to try and seek the legislative and bureaucratic clout to impose the department's views on other departments and other sectors of society. The other approach is to develop the knowledge, expertise, and networks to infuse ecosystem considerations at all policy-making and resource-management levels. The first approach would follow a "power-over" strategy, while the second would follow an "influence with" strategy.

It seems to me that the final report of the federal Inquiry on Federal Water Policy places too much emphasis on the "power-over" strategy. Perhaps more would be gained by building on the department's existing science capabilities and by ensuring that this resource is available to those making the fundamental policy decisions affecting the way we use and abuse the rest of the ecosystem. In this way, the department would be serving as an environmental secretariat on behalf of the federal government.

If the climate for the practice of water research in the Department of the Environment is to be improved, it seems clear that the institutional framework within which the water research is housed needs to be changed. The changes should reflect a conscious decision to focus the research effort on developing knowledge and expertise to deal with the important current and emerging environmental issues. In the process, it is important to address national needs for knowledge and expertise and not simply the water management mandate of the Inland Waters Directorate.

I can envisage a variety of possible reorganizations involving more or less reallocation of ecosystem research functions from existing units within Environment Canada and elsewhere. The options could be arranged in the following order: a) increasing the influence of the research function within Environment Canada; b) increasing the ability to influence clients outside the Inland Waters Directorate; c) increasing the influence of policy considerations as compared to resource management functions; d) increasing the ability to carry out interdisciplinary research on environmental issues of national interest; and e) increasing the ability to carry out cross-media research on the basis of national need without first creating complex interagency coordinating mechanisms.

Within the Canadian context, it seems to me that a federal crown corporation is the preferred framework for housing the "core" ecosystem research function. An Ecosystem Research Board of Canada, with a strong mandate similar to that once available to the former Fisheries Research Board of Canada, would provide a suitable framework for long-term ecosystem research. Such an entity might be created, initially from elements of existing research units in federal departments, agencies, and crown corporations, including Environment Canada (DOE), Fisheries and Oceans (F&O), and, perhaps, Agriculture Canada (CDA), Health and Welfare (H&W), Energy, Mines and Resources (EMR), Supply and Services (DSS), Atomic Energy of Canada (AECL), and the National Research Council (NRC). It would be headed by a Chairman of the Board who would report to the Minister of the Environment or to Parliament through the minister.

At the same time, there are many, less revolutionary changes that would go a long way towards addressing many of the more fundamental problems. An Environmental Science Service headed by an ADM in Environment Canada, or even an Environmental Science Directorate headed by a Director General, would reflect a serious commitment to address the underlying problems with the management of the environmental sciences in Canada. Either option would enhance our collective ability to manage the uses and abuses of freshwater ecosystems in a comprehensive and anticipatory fashion.

Comments by Jean-Louis Sasseville (abridged)

In the context of the quest for efficiency, Peter Pearse's paper represents a major step towards acknowledging the existence of important institutional objectives that are sought within a political, sociocultural, and economic context that is characteristic of the public production process. While Dr. Pearse's presentation is highly normative in content, it is not simply a plea to incorporate economic objectives into water management. It presents a skillful and realistic analysis of those areas where it would be appropriate to improve management procedures or to develop and rationalize the many legal and administrative arrangements within the framework of economic analysis, while still taking into account the wide geopolitical differences in water management problems, making good use of institutional experience, and stressing those improvements which are the least costly in terms of "political and administrative effort."

There are now new opportunities for developing more-effective water management policies. Dr. Pearse points out that it is more essential than ever to use the concepts of demand management and consumer price management in order to ensure the protection and enhancement of water resources, since a healthy environment is inextricably linked to good economic performance. He reviews the advantages of the price system for allocating resources and goes on to discuss the very delicate problem of property rights as a selfregulating instrument of water use. He criticizes the misuse of investment subsidies for public infrastructures as well as the prescription to industry of standards for pollution control equipment. At the same time, while noting the simplicity of use and relatively good results of quality standards, he deplores the economic loss that results from the blanket application of these standards to all of Canada. Lastly, he examines the advantages of using crown corporations to manage water resources.

At first glance, the economic approach to public water management championed by Dr. Pearse appears to be more effective in according water its full social value than is the present institutional system. While I am also in favour of a sociological and economic approach to water management, I must nevertheless point out that the arguments supporting this approach are not always adequate and that the concern for the efficiency of current measures tends to overlook the fact that past government decisions were based on quite legitimate considerations.

My comments will explore this approach, covering such topics as the concept of the watershed as a management unit; the presumed superiority of economic analysis in public management; the problem of reconciling economic and institutional objectives; the importance of the political market in managing common-property resources; and a proposal to consider institutional renewal from an information perspective.

In identifying the watershed as the basic management unit – i.e., the unit on which the legal and administrative management framework will be based – Professor Pearse recognized that the watershed defines the natural "limits" within which the market for water use can be established. Thus one can conceive of an institution whose mandate would consist in creating and maintaining a user market designed to redistribute costs and benefits "equitably" among users. But this would have to be accomplished without discrimination, without conditions, without any room for manœuvre . . . or almost.

It might be asked whether such an aritificial market for water uses represents a practical solution to the problems of watershed-based management. Despite the vital nature of the resource, it must be recognized that once domestic and industrial needs are satisfied, its importance to regional economic activity is minor. An approach designed to base the full social value of water on the watershed would encounter serious difficulties, especially if it were to contribute to increasing its cost well above the figure determined by the current balance between production and welfare inputs.

In addition, one might well question whether it is appropriate to reorganize water management within the current framework of a disorganized and apparently inefficient system of institutional arrangements. The current concerns about water management are a reflection of prevailing social and economic conditions rather than of either economic analysis or integrated planning, even though a preventative approach is considered superior in principle to a react-and-cure approach. So, it is not surprising that water management is subject to various jurisdictions or jeopardized in part by inadequate regulation and a more or less consistent set of institutional arrangements. Depending on the local water situation and the social and economic conflicts connected with water use, water management takes up its fair share of public and government attention.

Finally, there may be unforeseen obstacles connected with administrative reorganization. For example, in an artificial market the implementation of pollution control provides a collective benefit, but this benefit generally does little for those who pay for it. Assuming that a consensus should be sought before administrative reorganization takes place, how is it possible to reach agreement on allocating the costs of producing this collective benefit when most of the benefit is exported to downstream areas within and beyond the watershed?

In summary, the watershed is already the conceptual unit used by water management institutions. Should it also become the unit around which they are structured organizationally and functionally, this should not inhibit activities for which water is a means or a support, rather than an end in itself, nor should it fail to take into account the diverse interests of those citizens who pay in order to benefit from water resources.

One cannot but observe that the strategies for improvement proposed by Dr. Pearse are based on two assumptions (which may be quite valid!). First, he assumes that economic efficiency is the standard by which government actions are to be judged, in preference over the many other standards that are now used in the development and implementation of water management. Second, he assumes that economic goals are compatible with political, legal, and administrative objectives, both as they exist now and as they may evolve in the future.[21]

I do not share these assumptions, however, at least in the form that they take in economic analyses of government policy making. On the one hand, there are difficulties involved in carrying out government programs conceived under the dogma of economic efficiency, because of the dissatisfaction aroused among those who lose in the process. On the other hand, there are intrinsic limits to economic analysis: it seems to be impossible to adequately include in such analyses the elements determining the orientation of the decision-making process, the conditions under which the decisions are made, and the conditions under which their impact will be felt.

Because certain measures, such as the implementation of a market-based pricing system, are irreversible in practical terms, the presumed superiority of this type of measure should be assessed in relation to the value, in terms of social efficiency, of other measures that preserve the full range of administrative options to which the public, elected officials, and institutions are generally committed.

For example, water-demand management is already implemented in some municipalities through simple and probably quite effective mechanisms. A carefully designed program whereby water pressure is lowered during peak demand hours, coupled with an information program on lawn watering and swimming-pool maintenance that relies on civic cooperation, can succeed quite well in controlling consumption. These methods are popular with the public, who thus feel that elected officials are doing a good job of defending their interests. Obviously, we are not speaking here of economic efficiency, but rather of political and administrative effectiveness.

One aspect of the second assumption concerns the ability of government institutions to give priority to the economic significance of their actions over their own existence – i.e., over their legitimacy, their internal structure, and their essential needs, which are all basic elements of their self-interest. Paradoxically, it was the controversial economic analysis of bureaucracy and the firms[22] that revealed that there are within institutions factors that are distribution of marketed (private) commodities, it was found, were paralleled by inefficiencies in the nonmarket sector, in the form of bureaucratic self-promotion, political patronage, and so on.

In proposing avenues for the development of a Canadian water policy, Dr. Pearse points out the difficulties in setting up a comprehensive management strategy. The constitutional division of authority and the fragmented nature of institutional arrangements in Canada and in the provinces and territories constitute an insurmountable obstacle to formulating a single approach to resource management. Too many divergent interests are involved, and the regional economic disparities that result in a multiplicity of resource management problems and solutions are very wide.

The challenge lies in identifying, among the appropriate solutions, those on which consensus can be reached. This challenge is formidable. On the one hand, if economic theory is used to propose obvious improvements in management practices, there is the danger of ending up with policies that cannot be implemented because of the institutional distortions they would generate. On the other hand, if priority is given to those current management practices which appear to be the most acceptable to the public, governments, and public institutions, is there not a risk of moving away from the efficiency standards prescribed by economic theory?

I believe that policies should, above all, capitalize on the diversity of approaches and actions in order to solve social problems. In seeking to achieve their efficiency goals, they should rely on the institutional experience gained (both in government and elsewhere) as a result of the interaction between the various actors in the management process. Policies must also rely on the integration of good management practices and proper user behaviour into social and institutional cultures. In short, policies in the water sector should be designed as a step towards efficiency in conservation and protection initiatives rather than as a rational framework for management activities.

In order to do this, we clearly must avoid judging management activities solely on the basis of their conformity with economic theory. The framework for program analysis must be expanded to take into account other approaches and objectives – the democratic process and government action; the limits imposed by legal and administrative factors; the behaviour of institutions; and, finally, the societal approach, which blends these various behaviours and attitudes into one culture.

Table 3-1 summarizes a subjective analysis of the "degree of compatibility" of Dr. Pearse's proposals. Only the concept of ownership rights initially appears to be incompatible with management practices and activities that lead to water management problems. Thus we must agree that Dr. Pearse's proposals seem plausible. However, because of the ongoing debate between economists and decision makers on these issues – the former advocate a single rational framework for government intervention while the latter firmly favour the use of existing mechanisms whose performance and political and administrative limits are known – it is time to plant the seed of new management ideas and to let management institutions try out and assess new instruments in the appropriate sectors.

The solution championed by economists, and supported by Dr. Pearse in his presentation, is that, if intervention leads to the solution of water use problems by favouring a strategy based on the market value of the resource, then this action will be efficient and should lead to a better quality of life.

It is important to understand the reluctance of governments to adopt such an approach in dealing with common-property resources and public goods. The

Table 3-1

Subjective Assessment of Level of Compatibility of Pearse Proposals with: Perception of Water-Related Problems, Modes of Government Action and Institutional Arrangements (in Quebec)

Components of process	Comments (or proposals) of Mr. Pearse	How problems (or solutions) are perceived	Types of intervention	Institutional arrangements
Policy possibilities:				
Watershed as management unit	Management principle	+	+	–
Systematic evaluation	Essential to efficiency	+	–	+
Truth in pricing	Basic demand-control instrument	–	0	0
Ownership rights	Almost indispensable for optimum division of social costs	–	–	–
Government investments	Must be accompanied by economic controls to avoid wastefulness	0	–	–
Subsidies	Lead to distortions in use and in cost sharing	n.a.	n.a.	n.a.
Equipment standards	Incompatible with the economic realities of business, average performance	+	+	+
Quality standards	Easy to use, average performance	+	+	+
Government enterprises	Optimum resource allocation	+	+	+

+ Compatible.
0 No difference.
– Incompatible.

production of clean water is a government responsibility and is subject to the same criteria as other public goods (health and education, for example); at least, it is so perceived in practice. Even though an in-depth analysis would reveal significant differences between health and education and water quality as public goods, it must be admitted that the analogy stands up in part, in terms of the attitudes of both the public and government. This is a major obstacle to establishing a market cost and allocating water resources equitably among users.

In the case of a common-property resource, the market is artificially maintained by a system of administrative and legal arrangements and controlled by another body of regulations that define the scope for government intervention. In my opinion, the information problems resulting from the creation, maintenance, and control of this artificial market appear extremely difficult to overcome; thus, information is a factor that inhibits optimum performance. Economists seek to get around this problem by proposing the adoption and distribution of water ownership rights, which would considerably simplify the problems of cost adjustment and use distribution. But, as we have seen, the privatization of water usage arouses little enthusiasm.

What information is required by decision makers and administrators in order to improve the efficiency of management practices? What is needed is information that tells them what public opinion and expectations are, as well as informing them about quality control costs, the cost of damage associated with the various uses of the resource, user costs, cost sharing, public willingness to pay, regional and local values, preferences and priorities, environmental change, and so on – in addition to much of the information that is currently gathered and processed by various management organizations.

In my opinion, by failing to single out information as a possible means of improving water management, Dr. Pearse has overlooked the most readily available method in the quest for administrative and economic efficiency. The information approach respects the major thrust and historical legitimacy of the current management process, and it can bring about significant changes in operational patterns, without drastically altering present attitudes more quickly than desired or possible.

By developing an information system based on data-processing technology, decision makers would be able to assess the best available options for orienting administrative structures and insitutional arrangements. In my opinion, this new compatibility would, in itself, produce the desired changes in the attitudes of managers and users, and would help to correct the numerous deficiencies brought to light in Dr. Pearse's presentation.

Although it is a realistic treatment of the subject, Dr. Pearse's paper appears to follow those who consider economic analysis as paramount and who believe *a priori* that this theoretical and pragmatic approach is compatible with organizational and institutional structures, the public production process, and user behaviour. Since most of the proposals discussed would involve major changes in organizational structures, institutional arrangements, or government information-gathering and intervention, in addition to requiring the cooperation of other levels of government and various water users, and given that attention is now being focused more on econmic development and cost cutting, it seems clear that an exclusively economic approach to water management will seriously impinge on the current structure and on the traditional pragmatism of institutions.

However, more in-depth analysis aimed at discovering the human, technical, and institutional factors that encourage efficiency in water management could prove to be of great assistance. It would help identify the areas where change could be undertaken without radically altering current approaches. For example, the development of *information systems* better adapted to the economic, social, and cultural aspects of water management would allow institutions to create and experiment as needed with new and more-efficient legal and administrative mechanisms, which would nonetheless respect the various overlapping objectives that compete for consideration in the management of common-property resources.

Floor Discussion

Question: *Often a company faces a conflict between the priorities of environmental protection and short-term economic advance. How can we deal with this?*

P. Pearse: If we recognize the convergence of interests in the environment and the economy in the longer time frame, then one must build into the firm's decision making the economic incentives to economize on its demands for water in the same way as it is economizing on the expensive things like land and labour and capital. One refines the systems of rights to use the resources and charges for the use of them. In that way we will avoid the overuse and waste that we all so deplore.

Question: *Professor Sasseville has suggested that the gains from watershed management are not going to be commensurate with the costs of setting up the arrangements. In addition, the political problems generated by some of these arrangements, regarding job loss, for example, are problems that are going to have to be resolved at the provincial or regional level in any case. What weight should be attached to these concerns?*

P. Pearse: There is a long history of attempts to manage water on a coherent watershed basis, and the results have been mixed. The North American experience has been so uninspiring that the trend now is toward retrenchment. The failure probably stemmed from early attempts to plan comprehensively in an overly ambitious and inflexible manner, so that the plans proved impractical. We must, of course, recognize the interdependence of uses on a stream. But in Canada most watersheds do not have the heavy demands that would justify elaborate management schemes. In those few cases where demands are focused and urgent, new institutional arrangements may be needed that can take into account those interdependent uses, employing modern technology such as sophisticated computer modeling of systems. A good deal of intergovernmental cooperation will be required.

4 Forest and Wildlife Management

Presentation by Gordon L. Baskerville

Canada is not in any danger of running out of forests. Indeed, the total forest area of the country may be increasing. Nor is there any likelihood that Canada will run out of forests in the foreseeable future. On the other hand, there are individual mills in Canada that are currently short of raw material of the quality they would prefer, and there are many specific mills that will not have adequate amounts of the inexpensive, high-quality wood they are accustomed to using, for a period of time within the next few decades.

Canada has a problem with its forest economy not because there are insufficient forests, but because there will be a temporary shortage of certain specific raw-material qualities in certain specific locations in the next few decades. The difference is crucial. It is easy to fix the problem if it is just one of being short of forests: simply plant a new one. However, the problem is the kind of forests out there now or that will be out there in the future, and the ability of present and future forests to produce specified raw-material qualities at the same rate as they are harvested over an extended period of time. This problem is much more difficult to fix. To reinforce this point, let me state that Canada is not in any danger of running out of deer habitat. However, there are deer herds that do not have the best mix of habitat now, and there are many herds that will be diminished in numbers in the next few decades because they have insufficient food (raw material) of the type they have become accustomed to feeding on in recent years.

The problems in the Canadian forests, both with respect to wood supply and habitat supply, center on quality more than on quantity, and they will confront us for a limited period at some time in the future. These problems are important to Canadians because of the economic dimensions of the forest-based industry. However, because of those same dimensions Canadians historically have adopted an economic perspective on a resource that is biological, they have recently developed dangerously simplistic views of both the problems and the solutions. The real and potential economic problems are well known in terms of jobs and revenues. This paper will attempt to provide an understanding of the underlying biological basis of these economic problems.

Where We Are

For Canada to begin to address its considerable forest-management problems, it is essential that, as a nation, Canadians grasp the paradox of current plenty yet existence of problems. In the midst of plenty Canada has problems, some immediate, but mostly in the future. The key is that the problems relate not to the amount of forest, but rather to the *kind* of forest and, more importantly, the *kind* of forest that will be there in the near future. Whether the discussion is about wood, deer, recreational opportunities, or whatever, the situation is the same. The problems are, by and large, fixable, providing that the root causes are patiently addressed rather than superficially papering over the symptoms with comfortable cure-alls.

The current publicity being given to Canadian forest problems can be helpful in mobilizing the necessary corrective attacks, but it also leads to a very high risk that the wrong problems will be "fixed." The media focus is heavily on correcting symptoms, dealing with simple problems that exist locally or on paper but are not really out there in the woods. The focus seems to be on achieving instant societal satisfaction, which can be announced on the next newscast in passing to the next apprehended crisis. In reality, we must fix problems that are fundamental to the forest structure, and these will require considerably more thought than the simple approaches imply. A simplistic approach may be easy to understand, but it can be wasteful if manpower and dollar resources are misdirected and ineffective. The real problems in the woods have a large lead time factor in them to allow for the necessary time in restructuring a slow-changing biological system. While they are still largely correctable, the time window for action is closing rapidly. Canada does not have much time to waste on posturing and cosmetics.

The current simplistic cry is: Plant, plant, plant! However, it may be that we are overplanting in Canada right now. We could be overspending on this treatment because we started fixing the problem (a simple view of it) before we had a definition of the problem. Actually, if the problem is defined at all in this simple context, it is that we do not plant enough, and hence the solution is to plant more. Possibly the problem is too much cutting rather than too little planting, or cutting in the wrong places or at the wrong times, or a mixture of these and other causes. The point here is that if Canada does not know clearly the nature of its forest problems, how can the adequacy of the remedies be determined? How can the amount of money required to fix a problem be stated in advance of a statement of the problem itself? The problems are big, both economically and biologically, and their very size cries for a more rigorous specification of their nature. Planting is important, but it is only part of the solution, and it is not sufficient by itself.

The problems with respect to wood availability and wildlife-habitat availability are essentially structural problems. The present structure of the forest is such that the rate at which wood or habitat is available now is adequate. However, the structure changes as the forest develops over time, partly due to natural change with time, but also because of the interventions of man. There will be a period in the foreseeable future when the rate at which wood or habitat become available will be inadequate. These structural problems are unique to each of the forests. There is not a forest problem in Canada, there are many problems in as many forests. Further, these many problems have many dimensions. Some are economic; some relate to pattern of wildlife habitat; some are environmental; and most are combinations of these. The problems are highly variable from place to place in terms of their biological basis and in terms of the way they are perceived and measured. Despite – or because of – the media blitz on the topic, the Canadian public is misinformed about both the nature of forest management problems and the adequacy of solutions.

What is needed out there in the woods is not a media-type word (or picture) solution, or the cosmetic treatment of an annual-report solution, but rather an actual solution on the ground in the forest. Achieving this will take much effort, beginning with a real understanding of the problems themselves and leading to long-term concerted action on the ground.

Canada Has the Forests It Deserves

Canadian forests are in a bunch of messes. The plural is used here intentionally. Some 95 per cent of the forest is owned by the 10 provinces, and this land is divided up into a large number of units with various management arrangements. There are at least 150 of these. In addition, there are many more industrial ownerships, and the nonindustrial ownerships number in the hundreds of thousands. There are a variety of forms of federal forest as well. There are many forests in Canada's forest. All in all, a wide variety of forest types, with a wide variety of ownerships and a wide variety of management goals. There are many forests, and a unitary "Canadian forest" exists only as a figment of calculation.

Canada, or rather Canadians, have used these forests to manage economic problems. Local and regional economies have been built and bolstered on the use of the local forest. What has been done in these forests has been whatever was best for developing the contemporary local economy. As the forests became altered in form or structure by economically driven activities, the forests no longer yielded the original mix of raw-material quality or of wildlife habitat. This was overcome by such simple expedients as using different species or different sizes, or, best of all, just going a bit further afield for the raw material or the wildlife. Supply problems in the forest were fixed technologically, either by building a road or by building a machine. These technological fixes were aimed at maximizing current economic gain or benefit to society. Gradually, processing plants ran low on the quality of raw material they preferred at the price they preferred, but it was always cost-efficient to move on to the next forest or to the next species in the current forest, rather than to *manage* that forest. Canada has built its major exporting industry by exploiting its forests.

It is not at all difficult to understand why there has been little forest management in Canada. Forest management in the Canadian context has been a constraint to economic development. Anything that prevents reducing the cost of raw materials is a constraint. Forest management increases the cost of raw materials, and Canadians minimize costs.

As Canada used its forests to develop local economies, real-time economic gain was the sole indicator of performance. The forest management plans of, say, 1955 were overridden by decisions that made sound economic sense at that time. Concern for the future was not expressed, or else concern was rationalized with such catchy phrases as: "If we can't be economically competitive, we won't need the forest, so lets get economic first, then we will manage." That future so easily rationalized in 1955 is today. Today *is* the future of 1955, and the same phrase is heard today. For the Canadian forest industry to survive, it must be based on a productive forest, but it must also succeed in the international marketplace.

Today, Canadians tend to wonder why there was no resource or environmental management in the past, often suggesting that these are new concerns. Resource management, wildlife management, or environmental management were (and are) all constraints to economic productivity. Expenditures on these activities have all been minimized as a result. However, even a casual review of the past will reveal that there were forest management plans in 1955, and indeed well before that time. Some of these plans were quite sophisticated and show that the decision makers of that day were provided with a decent picture of what the future in that distant year of 1985 would look like. True, these plans lacked the current high-tech buzz, but they had been put together with considerable thought. Looking back, it can be frustrating to see that most of the forest problems faced today were foreseen in those early management plans – perhaps not in today's terms, but the signals were there. The plans that contained this foresight never made it into the woods. They largely were relegated to shelves, where they were to gather dust until that day came when the economic base was "established" and management became affordable. Unfortunately, they stayed on the shelf.

Management plans on the shelf instead of in the woods meant that the best of ideas never got implemented on the ground. Because it was a constraint to economic productivity, Canada did not choose to *make* forest management happen in the woods, for if we did, then the goals of those plans must have been what we have today in the forests. Again, even a casual review will show that the goals in those early plans were gold-plated, leaving one with the conclusion that Canada ignored its own forest-management advice because it believed forest management was an unnecessary (low-priority) cost.

Canada has benefited handsomely from its forests. For many decades the forest-based industry has been among the highest tax generators. While the forests have produced much in the way of revenues and wages, not much has been put back into them. Total expenditures on the forests have represented an insignificant percentage of the revenues. There have been many appeals to redress this imbalance. Each time there has been a push to have the expenditure on the forest increased, there has been a socially valid reason why that should not be done. First, it was the greater need for rural electrification; then, it was the greater need for paving secondary roads; then, it was the greater need for consolidated schools; then, the greater need for regional hospitals; and so on. In short, when it came to spending the revenues from their forest, Canadians, who happen to be the owners of the resource, had other greater needs than the maintenance of their resource.

There are some really fine starts at forest management in Canada, but these are scattered, and the bottom line is that, nationally, we are in about the same shape in 1985 as in 1955, except that in the intervening 30 years the problems have become more severe and the solutions have become more expensive and fewer in number. To an alarming extent, Canada still has plans on the shelf, and economic exploitation in the forests. This makes one wonder if Canada and Canadians have really changed, and if so for how long? Will the current hype for forest management outlive the current media kick on the topic? When the media and the public move on to save fiddleheads, or whatever the next crusade is, will the current diversion of revenues to the management of Canadian forests suffer a relapse? What will happen then to all the money currently allocated to planting trees?

There is no doubt that Canadian forests urgently need active management, and they need it in the woods, not just in plans. Economically driven exploitation has led to species changes in the forests. It has altered the forest structure so that large trees are no longer available at the rate they were as recently as in 1955. The cost of delivered raw material is strongly influenced by the average size of the trees available for harvest. Canada has built a "road to resources" to just about all the possible sites for exploitation. There are few, if any, places left to go. To continue the industrial economies built on this activity will require management of the forest.

Canada has to manage the forests to survive. If Canada wants to maintain the economies it built by using the forests, that is possible, but there will be a price, and that price is resource management. The problems of quality with industrial raw material, wildlife habitat, and environment that we face in the Canadian forests are amenable to correction by management, but that cannot happen unless management is seen as a provider of benefits rather than as a constraint to economic development. The economic development we have gained from the forests cannot be sustained more than a few decades without forest management. With management Canada can have the continued benefits of its forests (economic and wildlife) for as long as we have the will to manage.

Managing: Getting Started

Except in the most trivial sense, it is not possible to state a solution that, if implemented, would lead to a Canadian forest future that is all roses. In fact, this sort of all-purpose/no-purpose solution is precisely the sort of thing that engenders either management paralysis or reckless spending. Simple solutions look simple; it is just not possible to implement them in the variable forests. Whether we like it or not, Canada is faced with a complex of problems in its complex forests. If Canadians insist on simple solutions, they will get exactly the forest result they deserve, just as they have in the past. There are many different problems, and there will be many different answers. One brief paper cannot begin to state these. The best that can be done is to urge avoidance of overgeneralization and the adoption of a process that will identify specific problems in specific forests and permit the design of specific solutions to these specific problems.

A best place to start is with a discussion of what we want to manage and who implements management.

Management is carried out (or not) on a specific forest – that is, on a defined area of forest land. This apparently simple fact is easily ignored, but if an area is not designated for management, you can be sure that management will not happen there. Management occurs where someone has the responsibility and authority to intentionally take actions to initiate it. The boundaries of a forest management unit are somewhat arbitrary, but if they do not exist, it is not possible to assign management actions via the allocation of dollar and manpower resources. When you see a statement of a "forest management problem" that is not related to a defined forest, the problem is not defined at all; the solution, if it is offered, is not implementable because it is not known where it is to be implemented. This simple criteria for usefulness with respect to forest management enunciations eliminates most of the current public discussion of forestry in Canada today. We have to know where the problems are before we can direct solutions at them.

The second important point is to identify the managers. Again this may seem simple, but few forests have a single manager, no matter how convenient it may be to talk about manager in the singular. Even where one agency (or owner) controls a forest, there is more than one person in the decision-maker set. This results from the multiplicity of agencies to which Canadians have legislatively ascribed some measure of authority in the forests. At least a half-dozen federal departments and as many provincial departments have an influence on management decisions and therefore on actions, or lack thereof, in any one of our forests. I cannot imagine a situation where the manager is a single person. Always the manager professes that he would allocate dollar and manpower resources for management differently, but "they" prevent him from doing so. In many respects, identifying the set of managers identifies the forest being managed, since a manager can only manage within his span of authority and responsibility. The managers are the people with the decision authority to cause or prevent actions in the forest.

Identifying the set of managers on the 95 per cent of our forests that are crown-owned is a particular nightmare because of the variety of constraints, checks, and balances that have been imposed in the name of public protection. This mixture of authority and responsibility vastly increases the number of players and the probability that no action will be taken as the players engage in an "After you, Alphonse" routine. It is possible to identify the managers of a particular forest property, and it is necessary to identify them if we wish to have any degree of accountability in management or, indeed, in discussions of management. Misidentification of the set of managers makes it easy for all concerned to renounce culpability.

The third major concern must be with the definition of what the forest is to be managed for. Clearly, if the target forest itself and the relevant set of managers have not been specified, this is not possible in any realistic sense. Management goals stated out of the context of a particular forest, or those not embraced by the particular set of managers with the responsibility and authority in that forest, are at best ethereal. In 1985, forest management always has a complex goal. We are not seeking integrated approaches, for these have been here for some time. All that is at issue is what factors get integrated and what the relative weightings of these factors will be.

Often, one hears that Canada needs integrated management. What that usually means is that the benefit flow that the particular person wants managed has not been specified in any measurable context so that it *can* be integrated. It is not possible to deliver more if it is not possible to state what is being delivered now, and how the *more* would be measured. The forest manager of today is accustomed to integrating current wood cost, species mix, annual harvest constraint, machine availability, labour availability, wood from purchase sources, and so on, into his operating plan for the next 12 months. Integrating something else is neither innovative nor difficult, so long as the something else is specified in an integratable manner.

Failure to specify needs and wants from the forest in measurable terms has been, and continues to be, the main reason for factors being left out of management decisions. Nowhere is this more true than with respect to wildlife habitat. The wildlife elements of management goals have traditionally been constraints, or pious platitudes, or both. *More* or *better* habitat cannot be delivered by control of harvesting, if units of measurement for more and better are not given.

Current studies indicate that there are no insurmountable problems in integrating wood supply with wildlife habitat supply on a forest management unit when the temporal and spatial parameters of both wood and habitat are specified. Indeed, for deer the matter is almost trivial, so similar are the supply needs of pulp mills and the supply needs of deer herds when these are measured in terms of the availability of particular types of forest stand and particular stages of stand development across geographic area and across time. Certainly, any failure to integrate these factors no longer stems from any inherent impossibility, but rather is a reflection of insufficient effort of the managers (of the deer and of the trees) to state the measures of management effectiveness in measurable units, so that impacts can be assessed in other than the trivial qualitative sense.

Specifying what we will manage for means specifying the benefit flows that we want to influence and specifying the way these flows are to be measured in the real world of the forest. Goals that are not so specified cannot enter forest (or any other) management consideration except as constraints.

In integrated management the emphasis is on the measures of response. It is not possible to simultaneously maximize two or more factors. What is possible is to choose management regimes that lead to a "best" mix of benefits. This requires that the measures of the benefits be stated (not necessarily in the same units) and that relative weightings of the benefit flows also be stated. Specifically, the goal level of each and every factor is determined in the context of all the other factors since forest management interventions influence all of them. The goal of forest management in any nontrivial case is not to maximize one factor, but rather to achieve some best mix of several factors. It is neither wise nor meaningful to specify a binding target level for one single benefit flow *a priori*.

The most crucial step in management design is the forecasting of the reasonably possible futures for each forest, so that the managers can choose one and then attempt to influence events in that direction as the future unfolds. If discussion of management goals is entered with predetermined bounds on what is acceptable for one or more factors, it is virtually certain that no comprehensive management decision will be reached and that we will simply allow the forest future to continue to happen to us as it has in the past! This is equally true whether the overriding bound is placed in economic terms, as in the past, or in the newer coin of environmental override on decisions. In the final analysis, if people do not perceive gain in their terms (largely economic), they will not long support the diversion of dollar and manpower resources to forest management.

The key to the design of implementable management schemes is to display a number of reasonably possible futures in a format that enables all the interested players to see how they and their concerns fit into each alternative plan leading to the possible futures. These displays, or forecasts, can only be built if it is possible to specify what response would be achieved for each incremental application of the many "treatments." In effect, dosage-response functions are essential for each possible treatment, and if they are not stated they are assumed in any forecast of the future. All forecasts of the future are speculative, and all that is at issue is the degree to which we understand the presumptions upon which those speculations are based.

For any given forest the present forest structure embodies an integration of past actions (or lack of actions); thus each forest yields a unique forecast of future availability, even with all other factors constant. However, all other factors are not constant. The managerial set varies, the ownership of the forest varies, the benefit flows and the measures of these vary depending on the local situation, and so on. The bottom line here is that there can be no universal Canadian forest-management problem, nor can there be a universal Canadian forest-management solution. For each forest the problems and possibilities must be defined, and the designed management regime must recognize these local realities; otherwise, the management regime is doomed to reside on a shelf rather than become a medium for directed control over future evolution in that forest.

The role of forecasting in forest management design cannot be overemphasized. The problems faced today were created by a series of incoherent actions carried out over a long period of time. It took a long time to create the problems and it will take a long time to fix them. Clearly, management design must try to foresee problems well before they become reality if they are to be avoided by cunning choice of actions as the future unfolds. The necessity of lead time in the correction of structural problems in a biological resource is a fact of life. No amount of money can buy time. Therefore, it is essential to forecast (continually) in search of potential problems in order to provide the necessary early warning that will permit a timely response to an emerging problem.

Forecasting forest structural changes over time is the key feature of defining forest management problems. Forecasting the response of forest structure to various treatment regimes is the key feature in designing forest management to resolve both existing problems for which we have forgone the lead time and future problems for which we design preventive actions.

Any management prescription embodies a forecast of structural dynamics in the forest. If this forecast and its attendant assumptions are not explicit, then they are implicit; but in either case the assumptions are certainly there. Making the forecasts in an explicit manner renders the assumptions open to inspection, and there are powerful techniques for exploring the impact of error in these assumptions. Powerful as these are, they do not, and cannot, render the future certain. The future will forever be a subject of speculation for us. The best we can do is make our speculations clearly and logically in terms of the biological bases of forest dynamics.

It should be clear from the above analysis that Canada does not have one big forest management problem, but rather we are faced with a multiplicity of problems in a multiplicity of forests controlled by a multiplicity of managers. It is dangerous, if not downright foolish, to express these problems as a sum or average for the nation as a whole. It is dangerous whether the averaging is done across the spatial domain or whether it is done across the temporal domain. Forecasts that in total (or on average) show there is sufficient wood (or habitat) in Canada presume that mills in southern Ontario have efficient access to wood available in Alberta and that deer in southern Ontario have efficient access to habitat available in Alberta. Similarly, forecasts that say "on average" sufficient wood will be available over the next 50 years do not reveal that the average is obtained for a current oversupply and a future shortage. Ludicrous, yes, but this is precisely what is being done with the frequent blanket statements that adorn virtually every public commentary on "the forestry problem." Given the dimensions of this country, the error is hardly less ludicrous when the average is taken across a whole province. Clearly, the *pattern* of availability of wood supply and of habitat supply, in both time and geographic area, is more important than the absolute amount. Pattern has both spatial and temporal dimensions, and omission of either one of these from the problem definition or from the solution design renders a management prescription nonsensical or nonimplementable, or both.

There are several important messages here. Perhaps the most important is that it is about 50 years after managers start managing before the target forest is considered managed. That transition to management is certain to be traumatic in the forests of Canada, if for no other reason than that we will be forced to depart from word management and from pure economic control of our actions and actually make forest management happen in the forest, at considerable cost to current economic efficiency. In effect, the continued economic efficiency of the Canadian forest industry can only be assured by designing and implementing regimes to control the evolution of forest structure through this transition to management.

There are many forests in Canada's forest. Not all of these forests are in good shape with respect to entering the transition to management, but neither are they all in limbo. In a goodly number of places, Canadian forest managers are getting the necessary information together that will allow accurate forecasts of potential problems and the design of solutions that suit these problems. Further, the necessary dollar and manpower resources to implement the solutions are becoming available. Canadian forest managers have begun in many of Canada's forests to take the close look that is essential to problem definition and management design. Central to this work is information on forest structure.

Biological Structure of Forests

A forest is a hierarchal system. It is made up of trees, each of which is an individual organism of a particular species and grows according to its own growth pattern. That growth pattern is modified by competition with other trees and by treatment. A tree is measured in units like diameter at breast height (cm), total height (m), and total volume (m^3).

A stand is a community of trees, usually of several species. A stand occupies an area commonly in the range of 10 to a few hundred hectares and is characterized by its species mixture and its developmental pattern through time. The latter is conditioned primarily by the competitive interactions of its component trees and, of course, by treatment. The units of measure in a stand include volume (m^3ha^{-1}), density (trees ha^{-1}), species mix (%), and basal area (m^2ha^{-1}). Each stand has a developmental pattern over time and passes through a number of states that exhibit a pattern of volume or habitat, etc. over time. The amount of wood or habitat of a particular quality available in a stand at any time is therefore a function of the stage of development of the stand. Thus forecasting development for a stand permits forecasting the future availability of industrial raw material and habitat quality in the stand. The stand is the common level at which a person views the forest. A person can *see* a tree or a stand, and a person can measure them.

A forest is a group of stands usually rather extensive in total size, perhaps of the order of hundreds of thousands of hectares, but also embracing units as small as a woodlot. A major problem in dealing with forests is that they cannot be seen, as trees or stands can be seen, but can only be quantified in some abstract unit such as total growing stock on 500,000 ha. Measures of a forest include area (000 ha), total growing stock (000,000 m^3), and total annual harvest (000 m^3).

A forest is variable in that it contains more than one stand type and, within each type, more than one stage of development. Hence the dynamics of forest change over time and over its area are complex. Since each stand in a forest has its own developmental pattern through time, the temporal and spatial development of a forest is conditioned by development of its component stands. A forest is characterized, from a dynamic point of view, by a listing of all its stands and their current stage of development along their developmental trajectories. Forest structure can be depicted as a series of local developmental patterns (volume per ha, deer habitat per ha, etc.) and a distribution of each of the stands in each type along their respective developmental patterns.

Stand and tree level treatments constitute silviculture and include cutting, planting, pruning, thinning, fertilization, etc. Forest management is temporal and spatial control of silviculture and of all the other treatments. These treatments are applied at the local stand level to influence stand development and thus to accomplish control of forest level structure over time. Silviculture is a local consideration while management is a global consideration. Management control of availability (of wood, habitat, etc.) in a whole forest is achieved through the temporal and spatial application of silviculture and of a related set of local tools, so that the forest always contains stands at the appropriate stages of development. This is equally true whether the factor we seek to control is wood supply for a mill or habitat supply for a deer herd. Control of forest structure is essential to sustainability.

The Sustainability Issue

Most considerations of forest management include the notion of sustainability, either explicitly or implicitly. Everybody wants sustainability. Although ubiquitous, sustainability is a slippery word. Canada has "sustained" a forest industry for two centuries – but is what we got what we want? This *good* word is virtually meaningless without substantial qualification. To have meaning, there must be a specification of what is to be sustained, for how long the specified quantity and quality are to be sustained, what units will be used to measure sustainability, over what forest area, and with what treatments. If any of these qualifiers are left out, the notion of sustainability becomes as transient as one's viewpoint.

For whatever factor we might consider (wood, habitat, recreation), the central issue in sustainability is availability. To consider a factor sustainable, we must have available the quantity that we want, in the quality we want, in the places that we want, for as long as we want. Treatments are applied to the resource in the intensity, type, and location – and at the times – necessary to ensure to the degree possible that the desired availability will be forthcoming. To discuss sustainability in a nontrivial manner, it is clear that these temporal and spatial requirements must be stated in measurable units. The obvious point here is that we cannot have everything, everywhere, all the time. The temporal and spatial patterns that we seek to sustain must be specified in measurable terms if management is to be designed in a manner that delivers the required pattern.

A problem with sustainability is, in fact, a problem with forest structure. The productive structure of the forest must be controlled in such a manner that the rate of availability of the desired factors continuously matches the goal benefit flow. That means that the species mix, the stand types, and the distribution by stage of development for each stand type must be controlled, for these are the biological regulators of the availability of any feature in a forest. The productive structure determines availability, and the productive structure changes over time in response to the simple passage of time (aging of the components) and to management interventions.

It is necessary to forecast change in the productive structure of the forest in order to evaluate the degree to which the future rate of availability of a factor will match our needs. A problem with respect to sustainability is defined in terms of the structural changes it would be necessary to create by management intervention in order that the desired benefit flow rate would be met. If we can forecast structural change, we can forecast availability, and we can design management interventions to regulate forest structure to yield sustainability. If we cannot forecast structural change in a forest, we cannot take a designed approach towards the future.

Designing is the easy part. The hard part is implementation, on the ground, of the plan that results from our analysis of reasonably possible futures.

Act Local, Think Global

We see problems in the forest in two contrasting ways. First, we can visually see a local stand situation, such as a nonregenerated cutover. Such an observation is unambiguous with respect to the stand condition; however, it offers no information on the state of management in the forest as a whole. The evolving forest structure may (or may not) be such that this (or some) nonregenerating cutover does not pose a forest management problem. You cannot judge adequacy of forest management by looking at one, or some, stand cutovers. A forest management evaluation requires that the stand responses be in the context of the entire forest structure.

The second way we see a forest problem is more a perception than a visual experience. In this case, we sense that this forest will no longer support this mill. Here, the net effect of all the individual local stand steps over the entire forest, and over a period of time, has led to this perception of an economic problem.

Problems don't happen all at once, nor do they happen all in one place. People tend to overreact to the single stand events, and they fail to note the impact of these on forest structure. When an industry is seen at threat or a deer herd at threat, people forget that these symptoms are temporal and spatial accumulations of incremental alterations of forest structure in small local steps over periods of the past 50 to 100 years. Each of the thousands of individual harvests of small stands annually in a forest is such a local step. The ultimate supply problem that is seen is a summation of these steps into a forest structure that no longer can support the rate of availability that we desire for some factor. A pulpmill is at risk with respect to the continuation of its usual wood supply, or a deer herd is at risk with respect to the continuation of its usual food supply, but the real *problem* lies in forest structure.

These problems were created by local steps in specific forests, and they can be corrected only with local steps in the same specific forests. There is one major difference between the mechanisms of problem creation and those of problem rectification. In fixing a problem, the long series of local actions must be embedded in a coherent temporal and spatial strategy so that the actions in sum, and over time, correct the forest structural situation that is the fundamental source of the problem. It will take as long, or perhaps longer, to correct the problem as it took to create it! The corrective steps, the management prescription, must be thought out in the total forest context and not simply be yet another series of incoherent local actions. The steps must be designed by looking ahead at the changes we want to accomplish in the forest structure.

The essence of forest management design is: act local, think global – or act stand, think forest. The set of local actions such as cutting, planting, and so on, that will be carried out in particular stands over the decades of the planning horizon must be orchestrated in such a manner that the net result of their temporal and spatial implementation in the forest over that period will be the required change in the forest productive structure. Forest management design requires look-ahead planning with respect to what we want, where we want it, when we want it, all in the context of the dynamics of forest structural change.

By our local stand actions and lack of actions in the forest, we choose our global forest future. It is interesting to contemplate the degree of global look-ahead planning employed in, say, 1955. If the decision makers of 1955 looked ahead, was the forest we are currently experiencing their choice? Was there conscious choice about the future in 1955? Are we consciously choosing in 1985? Do we have conscious measurable goals for the global forest structure in 2015, or are we just intent on carrying out unrelated local actions? Will we let the future happen to us again, or will we consciously try to control the future as it unfolds? The control of the global forest future lies in the coherent control of those myriad local stand steps over the long haul.

Forest management is a very long-term commitment. It is a commitment to act local while thinking global, and this approach is a constraint to economic exploitation. Forest management costs money; it is not a free handout to the pure of heart.

The Tools of Forest Management

Temporal and spatial development in a forest can be regulated by use of four sets of actions or tools that the manager can deploy by making decisions. These local tools are: scheduling of the harvest, allocation of products from each harvest; renewal; and protection. These tools, which are applied at the stand level, constitute the necessary and sufficient set of local stand actions to regulate the productive structure of a whole forest over time. These are the (local) stand tools applied in the (global) forest context.

Scheduling consists of the determination of the total harvest, or use, that can be taken annually from the forest, in both the temporal and spatial dimensions. For example, scheduling states what stands will be cut and when they will be cut. This is the major tool in the regulation of forest structure. In the classic sense, scheduling produces a queue, or listing, of the stands that are to be harvested year by year into the future. Such a queue is based on forecasts of the development of all the individual stands in the forest, so that each can be entered in the queue at the appropriate time, based on its stage of development at the forecast time of harvest. If sufficient stands of the right stages of development can be entered in the queue continuously, then sustainability is achieved.

Allocation is the assignment to specific users of the various types or qualities of material (or uses) taken from the forest in each annual harvest as it is actually made. Careful allocation of raw materials to best end use is crucially important when supply will be limited for some period.

Renewal is comprised of the silvicultural tools discussed above, such as planting, spacing, fertilization, and so on. Many people have come to think of planting as itself constituting management, but planting is only part of one of the tools of management. Silvicultural treatments are used to alter developmental pattern in a stand in order that the stand may be moved up in the harvest queue, or in order that a better allocation of raw materials may be recovered from the stand when it comes up in the queue.

Protection is the set of activities used to prevent unscheduled harvests in the forest. Clearly, if a stand has been scheduled for harvest in, say, 20 years, and it is harvested by fire or insects this year, then there will be a break in the availability at some point in the future. The degree of the break depends on the forest structure and on how tightly scheduled are the future harvests of other stands.

The four tools of forest management are linked to each other across time and across geographic area. A schedule is prepared on the assumption that existing stands will continue to grow along their respective developmental paths. Stands are scheduled for a time when they are forecast to have available certain characteristics in terms of their development. Scheduling a plantation for harvest 20 years sooner than a natural regeneration stand is based on the expected development of the two stand types. Scheduling a maturing stand for 25 years hence presumes that the stand will be protected from insects and fire in the intervening period, otherwise the schedule is a hollow plan. In terms of biological dynamics in the whole forest, and over relatively long periods of time, the four tools are linked, and violation of these linkages rapidly invalidates any management plan on the ground. Indeed, it can be argued that forest management exists (we are managing) only where all four of these tools are being deployed. Where one or more of the tools is not being used, there cannot be reasoned (planned) control of forest development, and therefore there cannot be management in the sense of attempting to control the unfolding future.

Implementation of any of the four tools imposes a cost. If stands are harvested according to a schedule, rather than taken as the logger meets them in the forest, there is an increase in harvest cost. Careful allocation of raw material increases harvest cost. Renewal and protection activities result in costs. Under forest management, raw material for industry, or other benefits, will cost more than under exploitation.

The concerted application of scheduling, allocation, renewal, and protection over time and under both temporal and spatial control yields regulated change in forest structure. These tools are applied under planned regimes so that the net effect on stands over time is to alter the forest structure in the desired manner in order to achieve the desired flow of benefits. Acting locally while thinking globally with these four tools can fix anything in a forest, except lost time.

Can We Recover?

There is no simple answer to this question. In most Canadian forests, recovery is still well within grasp. It depends mostly on the amount of will shown during the transition to management. It depends on the players in all those forests and on their ability to define and address their particular problems. Certainly, the opportunity is there. If Canadian forests do not support the existing industry, the fault will be entirely on the shoulders of contemporary Canadian society. Failure will mean failure to define the problems, failure to design a plan, or failure to provide the resources and legislative control to ensure implementation of a plan.

The highest risk lies in failure to implement plans that are technically designed. Many of the problems require long lead times and this makes them hard to see, and it is very hard to establish the enduring commitment necessary to put the plan in place on the ground.

The second risk is the use of trivial goals and trivial management designs. If Canada continues to plant simply because that is a "good" thing to do, and not because it is a necessary thing to do in order to correct specified structural problems in particular forests, the probability is high that we will fix the wrong problems. The temptation here is to use one average problem analysis (perhaps carried out from the window of an automobile traveling at 100 kph) for all the forests in Canada and to apply the one solution from this analysis to all the forests. Even a casual review of the current state of the forests will reveal the futility of this simple approach.

The problems in each individual forest must be defined in terms of constraints to availability through structural analysis. The analysis must include all the relevant benefit flows. The problems must be cast in the context of real local people, with real measures that engender commitment and allow assessment of progress. The contemporary fad "report cards" are useless in this respect because they report without comparing the state of the forest to any goal form. They express value judgments that, while interesting, are hardly suitable for responsive design to control forest structure. In the end, it will all come down to implementation. The best plans are of no help if they are not implemented in the woods where the problems are.

The steps to recovery are deceptively simple. Given patience and the avoidance of silly solutions, the process of defining management areas and their associated problems is well under way in Canada. What Canada wants from its forests is not so clear, and there is a vagueness about how to measure progress, particularly in terms of wildlife. Rather than arguing about who pays, more emphasis is needed on what it is that costs. Full examination of the range of possible futures that Canada could have is needed. Then, in designing the forest management to get the future of our choice, it must be remembered that the target is moving, and therefore there must be willingness to adapt as the future unfolds. Canada cannot wait for science to do the forecasting. Available science must be used to review the forecasts for logic, and to isolate the sources of most threatening uncertainty. The local actions must be designed that will achieve the global goal, and then we have to work, work, work.

We Didn't Have To Be Here

In facing the future, Canadians would do well to remember that we have had forest management plans in this country for 40 years. The non-implementation of these plans has been partly due to failure of the proponents to lay out the management goals and guidelines in measurable units instead of qualitative rhetoric. But it is also because, even though we had the plans, we as a society just could not bring ourselves collectively to spend the necessary coin to implement them! This resistance will not go away. Canada needs the foresight to see through the current period of oversupply and define the future problems while there is still sufficient lead time to correct them. This is a problem of transition. We are OK now, and we will be OK in 60 years. The hard part is getting from here to there. That will take perhaps 50 years of commitment.

There are few, if any, problems in Canadian forests today that could not have been prevented by action, at modest cost, begun 20 years ago. Canada need not repeat the past. Canadians have to show that they care about resource continuity and that they are willing to pay for it. There are some biological problems that simply cannot be fixed, because the lead time has been lost. For these, reasonable technological fixes are in order, but this must be done recognizing what they are, and that it is a matter of industrial survival. More importantly, Canada must get at resource management on the ground. Past indecision with respect to resource management on the ground, where it costs money, has meant the loss of many options, particularly the simple cheap ones, but the job can be done. The wood supply from the forests of Canada can be managed. The supply of wildlife habitat in the forests of Canada can be managed. The environment in the forests of Canada can be managed. To the extent that we can measure these things, we can manage them. Whatever else, it is certain that in 2015 Canada will have the forests it deserves.

Comments by Marcel Lortie

I am pleased that the keynote speaker at this colloquium on the environment, Professor Gordon Baskerville, chose to address the issue of forest management. I believe that one cannot discuss the forest environment without putting our use of forest resources into a management context. I have been following developments in forestry issues fairly closely, and I share the opinions expressed by Mr. Baskerville in his paper.

Unfortunately, many Canadians are not on the same wavelength as Mr. Baskerville. Generally speaking, it must be admitted that we have taken for granted that forest management is something we talk about, but that we do not put into practice. The behaviour of some Canadians indicates that they have a quite different perception of forest management than that discussed by Professor Baskerville.

For one thing, there are apparently some people who feel that forest resources should not be used at all. Even though there are 300,000 jobs tied to the Canadian forest industry and even though there are spillover effects on transportation, taxation, the balance of payments, and so on, there are those who feel that our forests should not be logged and, therefore, that there is no need for management.

Moreover, the problem of protecting managed forests merits special attention. There are those who believe it is possible to log forests and implement silvicultural projects without paying particular attention to protection. There are those for whom the term "forest management" is the cure for all ills, and who are convinced that managed forests have no need of protection against fire, insects, or disease. Clearly, however, once management is started it is important to protect the investment in order to guarantee reforestation and new growth in the forest.

As Mr. Baskerville pointed out, we are not short of forests in Canada, but, at the same time, we are in the midst of a timber shortage. This point of view is backed up by a recent White Paper on forestry policy in Quebec.[1] Sawmills have been operating at reduced capacity or struggling to solve supply problems. The solutions adopted often suggest that these industries will soon disappear.

Even those who believe that forests should be harvested do not necessarily agree on the scope of forest management. Some feel that the shortage of timber that we are currently experiencing is artificial. Some have proposed cutting low-yield stands that were passed over during previous logging operations. Others believe the solution to timber shortages lies in constructing new roads to give access to previously untouched areas, usually to the north – always further north. This, unfortunately, is the prevailing opinion in some government circles; however, they are merely putting off the problem of looking after second-growth and developing forests. In all those cases, the costs involved in transporting the timber and in picking up pieces of wood and bark left behind are very high. It would probably be more productive, therefore, to enhance the production from resources closer to plants.

Some feel that better use can be made of our forests; the example of Scandinavia is sometimes cited, where stumps are collected. Naturally, people who are closely connected with wood processing tend to look for solutions to the lack of wood within the processing sector. In recent years, particularly as modernization proceeds in the pulp and paper industry, we have witnessed the move from conventional chemical-based technologies for making pulp to high-tech procedures that lead to greater productivity. Increasingly, attention is turning to lasers and scanners to increase the amount of wood derived from the sawing process. Also, research is being conducted to find ways to use timber that until now has been passed over, particularly shade-intolerant hardwood for wood fibre. Thus, from the viewpoint of those involved in processing, there is a consensus that the solution to the wood shortage lies more in utilizing raw materials that were ignored until now. These are valid solutions, and they represent measures that should be undertaken concurrently with silvicultural projects.

Finally, some people feel that wood is a commodity that Canada will eventually have to do without for a while. This point of view is clearly evident in ***Western Transition***, the report by the Economic Council.[2] It is suggested in the report, for all intents and purposes, that western forests should be used up as quickly as possible as soon as the Americans need our timber. When these resources are exhausted, we will turn to others. This attitude is much more widespread than might be imagined. Eastern Canada has gone through its reserves of white pine, followed by white spruce and black spruce, and will probably also eventually exhaust its balsam fir reserves. When all these are gone, we will move on to something else, probably shade-intolerant hardwoods.

The points of view surveyed above, which leave the impression that forest management is not viable, not acceptable, or not possible in Canada, arise partly because of the people themselves, who are too concerned about costs or too solicitous towards the industry, or who are victims of the myth of overabundance. They once believed, still believe, or would have us believe that Canada's forests, unlike those of other countries, do not need to be managed. It is only in the last 10 years or so that some forestry specialists have begun to express the opinion, based on their observations and research, that even if Canadian forests do manage to survive, there will still be a period of timber shortage that will severely affect the forest industry.

Unfortunately, some forestry experts have also claimed that Canada's program of forest management is designed to provide sustained yields. We have taken for granted that nature would replace the harvested trees. At the National Forest Regeneration Conference held in Québec in 1977, it turned out that most, if not all, of the provinces were heading for stock falldown.[3] This problem is relatively new in this country. There have been shortages of large trees, and the situation has sometimes been critical, but never before have we been in a position where we might be running out of wood, and so we have never had to practise forest management in a comprehensive way. Given that this is a new situation, given the attitude of some people who believe there is no need to manage the forest, and given the conduct of forestry specialists who long claimed that the forest was being managed although this was not so, it is not surprising to find that there are some negative feelings about forest management.

Clearly, the forest industry will be among those affected by wood prices once forest management is introduced. The price of wood will undoubtedly rise. But the federal and provincial governments would be most affected by the lack of a forest management policy. We estimate that in 1983 the federal and provincial governments either received (in taxes) or saved (in welfare and unemployment insurance benefits) $53 for every cubic metre of wood cut in the forests of Quebec.[4] This is a far greater amount than the logging revenues generated by stumpage alone and other fees of this type. Cutting off the flow of funds to the Quebec and Canadian governments coming from Quebec logging operations would result in a loss of $1.3 billion. Thus there are sound reasons for keeping the industry healthy.

Unfortunately, as far as the revenues or savings enjoyed by governments are concerned, forest resources are still viewed as a cheap resource, and efforts are made to lower its cost of production. Both the industry and politicians dream of making timber cost virtually nothing, because wood processing is connected with large numbers of jobs and large tax revenues. It is hoped that by reducing the value of raw materials, processing will bring in more and more money.

By devaluing raw materials, however, we are also, in a sense, devaluing those who work in this sector. It is not surprising that the forest industry treats forest workers as a vast pool of human materials to be tapped whenever that suits its purpose. Nor does it see any incentive to invest in silviculture, since the resources have no intrinsic value. This attitude may suit the purposes of certain governments, since it can sometimes be used to justify the existence of job creation programs that will not have to bear the burden of high production costs. But the consequences of such an attitude can be extremely harmful to small private-forest producers.

In Quebec there is a proposal for a new forest policy that would encourage the selling of private-forest timber. Unfortunately, when a private producer sells his softwood for pulp, he is barely paid more than the public-forest harvest value. Where this wood consists of hardwood produced for pulp, we estimate that the producer must spend over $5 to market one cubic metre. If the producer is forced to produce wood at a loss or at little gain while governments receive some $50 for each cubic metre of wood he puts on the market, clearly he will never believe in the need to institute forest management and silvicultural techniques. And even if owners managed to obtain more for their wood, it is not at all certain that they would be interested in forest management unless there was specific legislation aimed at private forests. But price stabilization and government subsidies to encourage forest management will be required before legislation on private forests and the implementation of silvicultural measures in these forests can be introduced.

The future for forest management is not a rosy one. Too many people simply do not believe in forest management; too many feel that forest resources do not have any intrinsic value. If we firmly believed in the virtues of forest management and the need to implement it, the temptation would be to turn the forest industry into a source of well-paying jobs. During the Halifax conference, I had a question for participants that I slipped in here and there, perhaps over a cup of coffee. The object was to find out their feelings on the potential of our domestic forest industry. The question was: "If one of your children decided to enter the forest industry in one capacity or another, would you support this decision?" The answer was a resounding "No." People do not see any future in this industry. If we see no future for the industry, we are certainly not ready to embrace forest management.

My comments have probably been too negative. Yet I must agree with Professor Baskerville. Certainly, I recognize that there have been positive developments, such as the present federal-provincial accords. I note that there are individuals in the political arena who are becoming increasingly aware of the importance of forest management issues. But we have been talking about the need for forest management for such a long time. I hope that future developments will be more positive than the tone of this paper.

Comments by Peter H. Pearse

Forests and wildlife resources have much in common. Both are abundant in Canada. Both have provided the base of our dominant industrial sector – the fur trade during our early history, and more recently our huge forest industries. Both are renewable and can be depleted or enhanced through management. In some cases, they are produced on a common land base.

This short comment examines some economic issues relevant to the management of forests and wildlife, with reference to several arguments raised in the paper by Dean Baskerville.

Dean Baskerville correctly emphasizes the need to identify "what the forest is to be managed for" and suggests that failure to do so has been a major deficiency of management in the past. His discussion throughout the paper implies forest management for industrial timber and deer habitat, but this fundamental issue warrants some elaboration.

Both forests and wildlife are capable of yielding a variety of goods and services, and can be managed to produce varying combinations of them. The most obvious product of Canadian forests is industrial timber of various kinds, which is an intermediate product in the production of paper, housing, and other final products. But some forests are also managed to produce consumer services such as wilderness recreation, and they can be manipulated to enhance water resources, fisheries, wildlife, as well as agricultural, aesthetic, and environmental values. In most cases, forest management is directed towards (or at least takes account of) several of these joint products.

Correspondingly, wildlife is managed for intermediate commercial products such as furs, commercial tourist services such as the guiding industry provides, noncommercial recreation in the form of hunting and viewing, and general environmental values. Wildlife, and the benefits wildlife generates, can usually be enhanced through judicious management of wildlife habitat, but it is important to recognize that the habitat is only the means to an end. The production of the relevant wildlife benefits requires much more than management of the habitat, just as the production of goods and services from forests calls for more than management of forest land.

Sometimes, but by no means always, wildlife and forest values are generated on the same site. In some cases they are complementary, where forest operations benefit wildlife species such as deer; in other cases they conflict, because species such as caribou and grizzly bears cannot tolerate the disturbances associated with typical forestry activities. In most circumstances, complementarity and conflict are matters of degree that can be influenced by management.

All this focuses attention on the fact that wildlife values, like forest values, have dimensions of both quantity and quality. Dean Baskerville has emphasized the importance of timber quality in managing forests for the production of industrial products. Correspondingly, game is usually managed to provide recreational opportunities in the form of hunting, and the quality of the recreational experience is similarly a major determinant of its value. It is determined not only by the quantity of game available, but also by the recreational environment, including such factors as accessibility and crowding. Failure to recognize these attributes of quality in wildlife-related benefits has probably been as serious a shortcoming of wildlife management in Canada as the lack of attention to the quality of timber in forest management.

Dean Baskerville is concerned primarily with the challenge of recovering from the legacy of past deficiencies in forest management. He does not identify precisely the present problems that have resulted from these deficiencies, but he gives us clues. The problems are big, and they are many. They are becoming more severe. They are complicated, and the solutions are not simple. They could have been prevented, and they are "fixable," but they will take a long time to correct, and the adjustment will be traumatic. They are related mainly to the structure of the forest and declining quality of available material.

These arguments raise at least two fundamentally important economic questions about the management of forest resources: How fast should stocks be depleted, and how much should be invested in renewal? The answers define the degree of past deficiencies in forest management and, more importantly, the appropriate directions of forest policy henceforth.

Early Canadians found vast tracts of virgin timber, and they undoubtedly harvested it under "economically driven exploitation." By the early years of the present century, the great white pine forests of eastern Canada were depleted, and more recently we have seen depletion of the original Douglas fir on the Pacific coast. A dramatic wildlife counterpart is the depletion of the great herds of plains buffalo.

Was all this disadvantageous? Did our predecessors run down the inventories too fast? Would present generations of Canadians be better off if the original forests had been saved or exploited more slowly? Analyses of economic development suggest not.[5] Resource-based economies grow by exploiting the staple resources, converting natural capital to man-made capital, increasing overall productivity in the process, and moving on to new things. And technological advances continuously extend the extensive and intensive margins of resource recoverability, alter manufacturing processes, and free us from dependence on particular resource materials by presenting us with substitutes.

Economic theory can identify the rate of depletion of a natural resource stock that will maximize its contribution to social welfare over time.[6] This optimum temporal pattern of use changes, of course, with changes in technology, market prices, and costs. But it can be shown that under competitive market conditions, private producers will exploit their resources in a manner that converges with the social optimum, as long as private and social rates of time preference do not differ, externalities are absent, and certain other conditions are met.

All the conditions of perfect markets are not met in the case of Canada's forest industries, of course. For one thing, most of the resources are not owned by private, rent-maximizing landlords. But it would be hard to demonstrate that, on economic grounds, exploitation of the original stocks of timber has proceeded too fast and that present generations would be better off if it had proceeded more slowly. Indeed, the Economic Council of Canada has argued (albeit controversially) that the harvesting rate in British Columbia has been too slow.[7]

Moreover, it would be hard to make the case on environmental grounds. The environmental impact of forest operations has less to do with the rate of harvesting than with decisions about which forests will be exploited and which preserved, how logging is carried out, and the reforestation and other silvicultural measures adopted. In short, the structure of Canada's forests has been profoundly influenced by the rate and pattern of harvesting over the past century, but it is by no means apparent that exploitation has proceeded too rapidly.

In any event, the relevant policy question is how forests should be managed and utilized henceforth, given the legacy of history. Forest operations in Canada are in various stages of transition from a dependence on virgin timber to second-growth or managed forests. This involves a major shift, because the original stocks typically contain timber of significantly different species composition, dimensions, and technical qualities than new stands. The extensive economic margin differs, because original stands that are profitable to harvest are often found on land that is not sufficiently productive to yield a positive return to forest cultivation. And a new intensive margin becomes relevant, namely the level of silvicultural effort that can beneficially be devoted to growing crops.

This transition involves a shift from what is essentially a stock resource to a renewable resource with quite different characteristics. It calls for quite different management.

Provincial governments have attempted to bridge this transition with sustained-yield policies that aim at maintaining a more or less constant rate of harvest. This presents a difficult problem, because virgin forests, having grown for centuries, usually contain much more volume per hectare than managed stands grown for only a few decades. As a result, the rate of harvest must decline as exploitation progresses from the original stock to the sustainable yield of new forests.

Thus the artificial sustained yields adopted for the harvesting of original timber (on which Canada's forest industry still mainly depends) are likely to be short-lived. The yield from new stands can be enhanced through silviculture, but this raises the question of the degree or intensity of silviculture that is advantageous to apply.

Silviculture, like agriculture, is directed primarily towards enhancing the production of commercial crops, and so it lends itself to conventional investment analysis. It is advantageous to intensify effort up to the point at which the incremental cost is just matched by the expected returns. Little analysis of this kind has been undertaken in Canada. But it is almost certain that in many areas it would suggest a modest level of management, and a modest sustainable yield, though the land may have supported substantial harvests of original timber. In other areas it may suggest higher yields under managed forests.

This is not intended to imply that Canada's forest industry must decline in any particular region. The point is that the resource management regime and the rate of harvesting that will maximize the economic benefits from original stocks of timber are likely to be quite different from those that are most beneficial in the production of subsequent crops. Yet, established forest policies, like classical forestry doctrine, seem to reflect a reluctance to contemplate these adjustments. Regulated rates of harvesting, which involve the most significant economic decisions of forest agencies, purport to be rates that can be sustained through the transition from original stocks to managed stands. And silviculture is viewed not so much as an investment in its own right as the means to support the predetermined harvest rate and the established industrial structure.

In recent years, the pressure on timber supplies associated with the depletion of Canada's original forest inventory has attracted unprecedented attention to the opportunities in silviculture and considerable governmental funding of this activity. There is now an urgent need for economic analysis of these opportunities to establish the appropriate level of effort and the priorities among activities. In Dean Baskerville's words, "forest management costs money, it is not a free handout to the pure of heart."

Floor Discussion

Question: *Are there any examples where forest management is working well?*

G. Baskerville: In several provinces, we are moving in the right direction. But remember that it takes, in my opinion, 40 to 50 years to get a well-managed forest. A couple of Scandinavian countries provide examples, but I am cautious about the transferability of that experience to Canada. If, as a society, you are willing to specify, for a private woodlot owner, when he cuts, what he cuts, to whom he sells, how much he spends on silviculture, then you may be ready for the approach adopted in Sweden. Nonetheless, there has to be a lesson for us in their experience. The Swedes have deliberately changed their industrial mix – the type of saw mills and the type of pulp mills – dramatically over the past 10 years. They have also changed their forest policy to match.

Question: *Are we not slipping into a Panglossian optimism that pricing will solve all environmental problems, that it will reconcile conflicting interests? There are wild animals shy of any kind of development. When do we choose the option of nonexploitation, of nonmanagement. Which regions should suffer the disbenefits of economic development forgone?*

P. Pearse: The economic incentive options for resource management are not a panacea. They won't solve all our problems. Where unique features of the natural environment are to be preserved from exploitation, this must be done collectively, through government. But I am skeptical that we can have areas of "nonmanagement," because we can't manage just a piece of an integrated environment. Human activity impinges almost everywhere. We cannot simply turn our back on nature.

G. Baskerville: To be effective we have to motivate people's self-interest. We cannot force the proper management of resources by passing laws that are not consistent with reality.

5 Management and Disposal of Toxic Wastes

Presentation by Donald A. Chant

It's a pleasure to have this opportunity to talk to you this afternoon on what I consider to be the single most important environmental issue facing Canadians today, or indeed any modern society – the issue of how to deal with the increasing quantities of hazardous wastes that are the by-product of our ever-expanding industrial activities. Throughout my talk I intend to use the Ontario Waste Management Corporation as a focal point and as an example of a positive way in which this issue can be approached.

OWMC is a provincial crown agency created by an Act of the Ontario Legislature in 1981 to develop a hazardous-industrial-waste management system for the province, including the siting, design, construction, and operation of a major waste treatment and disposal facility for the province's wastes. OWMC is not responsible for garbage, a municipal responsibility, or for nuclear wastes, a federal mandate.

OWMC spent the first year of its life studying and finally rejecting a site for its treatment facilities at South Cayuga, near Dunnville, which the government had selected prior to the creation of OWMC. The site simply did not provide the environmental conditions essential to safe operation. Since that decision, we have been engaged in two intensive programs: the search for a safe and suitable site for our facilities, culminating in our selection of a site in the Township of West Lincoln last September; and the selection of treatment technologies suitable for Ontario's wastes, and of the engineering design of our facilities.

In my talk today, I intend to move through the following topics: the need for waste treatment facilities, systems options, technical options, the siting of facilities, the eventual operation of our facilities and business development, and finally our timetable and the future. But first, I want to clear up a widely held misunderstanding. Concern is often expressed at the 60,000 chemicals now in use in industry and the 1,000 or more new ones reputed to enter commerce each year. These are indeed disturbing statistics, and we know far too little about most of these chemicals, but they do not relate directly to the hazardous waste problem: they are a separate issue. Contrary to public opinion, the majority of hazardous wastes do not come from the chemical industry: true, this industry produces its share but the problem of industrial wastes is much broader, including the waste generated by almost every industrial activity, from the giant steel and petrochemical industries to car and electronics manufacturers and, indeed, to local dry-cleaning or silver-plating establishments.

It is also important to understand that although we often speak of liquid industrial wastes, these also include a wide array of sludges or even solids, such as filter cakes, and PCB-contaminated equipment. This is very important with respect to the selection of treatment technologies.

Now to the issue of need.

The Presence of Waste

The creation of industrial wastes, or course, is not new in human experience. When our distant ancestors first learned the rudiments of metallurgy, the seeds of industrialization were sown. The Bronze Age was ushered in as many as 3,000 years ago, probably in China, and the Iron Age shortly followed, springing up in a number of places in Europe and the Near East. The wastes produced were inconsequential, of course, until the Industrial Revolution thrust itself upon the world, beginning about 200 years ago and still proceeding apace. The most important features of this explosive development with regard to wastes is not only that the amounts produced have increased exponentially but also that their nature has changed. Today we must deal not only with natural wastes, albeit in unnatural concentrations, but also with a wide array of wastes that themselves have no counterparts in nature, that are truly man-made. PCBs, for example, do not occur in nature, and the natural world, including humans, has been exposed to them for only 40 or 50 years. In summary, then, industrialization has resulted in the production of wastes not only of unprecedented quantity but also very different in kind from the substances to which we have been exposed over most of our million or so years of evolutionary experience.

OWMC has conducted one of the very few detailed waste inventories ever conducted anywhere – certainly the first in Canada – by means of over 1,000 personal interviews from among the 16,000 plants generating special wastes in Ontario. The survey results were extrapolated to estimate the generation expected from all plants in the province, using industrial distribution information from Statistics Canada and Dun & Bradstreet. These estimates confirm our earlier market estimates of 1.5 million tonnes of "special" wastes being generated annually by manufacturing plants in Ontario. We classify "special" wastes as those of a hazardous nature requiring special treatment and detoxification beyond their simple disposal into a sewer system or a municipal garbage landfill. This estimate is consistent with a very general survey conducted in 1981 by the federal government, which estimated about 1.6 million tonnes for Ontario and 3.3 million tonnes for all of Canada.

These wastes can be categorized into 79 different types, using the UCD system developed by the University of California at Davis. About 70 per cent of this total are inorganic wastes and about 30 per cent, organic wastes. Of the total 1.5 million tonnes, about half now receive some form of treatment, either by the generator himself or by the private treatment industry – say 750,000 tonnes, generally of the less hazardous, high-volume wastes – and using limited technology. About 8 to 10 per cent is recycled, and about 10 per cent is exported to the United States for disposal. The remainder is discharged untreated into our sewer systems or disposed of in landfills not designed to contain them. From these data, it is clear that about half a million tonnes of hazardous wastes in Ontario each year are not receiving the treatment they require, and often this total includes many of the most toxic and difficult-to-treat wastes, such as chlorinated hydrocarbons, PCBs, and the like. Ontario, indeed Canada, has no approved treatment facilities for PCBs, for example. Classified according to major industrial sector, estimates of the wastes produced in Ontario are as follows: primary metal industry, 30 per cent; chemical industry, 16 per cent; petroleum industry, 10 per cent; and transportation industry, 9 per cent.

Well, you may say, what difference does it make if about 500,000 tonnes of hazardous waste go untreated into the environment each year in Ontario – enough to fill about 12 CN towers? No one is dropping dead, and the environment seems to look all right still, save for a few beer cans and discarded car tires. There are many answers to this question, ranging from the ethical to the practical. Let me answer in scientific terms relating ultimately to human health.

These wastes – particularly the very persistent, man-made organics – can now be detected in virtually every form of life, from arctic polar bears to you and me. My body fat has detectable levels of many organic wastes, including PCBs and a host of other really unpleasant toxics; so does yours, and that of every other Canadian. Some of these toxics are known carcinogens and teratogens, but for most of them we simply have no toxicological data beyond the strong supposition that they will do us no good over long terms of exposure. But we do know that concentrations of many are increasing – in us, in mother's milk, in wildlife of all kinds, in our water, and in our soil.

The monitoring of wildlife tells us that, generally, as levels of contamination have increased so have the levels of tumours and cancerous growths in a number of Great Lakes fish species – for example, coho salmon, carp, suckers, and bullheads – and so has the incidence of reproductive failure in several bird species and in trout in Lake Simcoe. And scientists have detected PCBs in rainfall in Ontario, deposited on the leaves of field crops. I hardly need dwell further on this: it is a rare event when the newspapers these days do not have yet another story on environmental contamination – from leaking dumps (there may be more than 2,000 dumps of concern in Ontario alone) to the Niagara River and its sorry state.

The point of all this is that there are many signs that we are in serious difficulties, and the indications are that the situation is becoming worse. Some of these toxics come from deliberate human activities, such as the widespread use of insecticides and herbicides, but most come from our failure to treat and dispose of industrial wastes properly. The imperative is that this is no longer a matter of simple environmental ethics or of ecological radicals wanting to protect this species or that; it is now a question of thresholds of human health effects. And, though we know frighteningly little about most of these toxic wastes, we do know that many of them take years to work through the system: though DDT was banned in 1969, it is still present in wildlife, fish, and us, as are its equally disturbing breakdown products. Very long lead times are required in order to reverse the upward trends we see today: the wastes we put down the sewers today will be with us for many years. If all improper waste disposal were to stop tomorrow, the effects of the past would still be with us for a long time to come.

What Is to be Done?

It is obvious from this, then, that since we generate large quantities of hazardous wastes and they are posing a serious threat to us and to the environment, something must be done. But what?

There are a number of options. First, at the *systems* level.

For the sake of completeness, I suppose there is the Do Nothing option: simply to continue as we have in the past and consider environmental destruction and threats to human health as part of the cost of industrial activity. In view of the situation I have described, most people do not consider this a viable option any longer.

Given then that some action is required, many people have the impulse to demand that industry clean up its act. "Industry creates the problem – let industry take care of it." There are two responses to this. First, industry does not operate in a vacuum, separate from our society as a whole. Industry does not create its goods and services for fun: it creates them because we want them and are willing to pay for them (thereby, of course, enabling industry to make money). We want the TV sets, the cars, the dry cleaning, the film – in short, all of the material goods in whose production hazardous wastes are produced. And we enjoy the employment – and yes, the profits that industry provides in meeting these needs. I do not see this as an issue of guilt: industry is not guilty of anything because it produces the things that we want, and we are not guilty for wanting them. Rather, it is a question of responsibility – shared responsibility to take care of the down side of industrial activities because we, all of us, enjoy the up side benefits of these activities.

The second response to the demand that industry must take care of the problem is a very practical one. As I said, there are more than 16,000 industrial plants in Ontario producing hazardous wastes. To suggest that each plant should have a little hazardous-waste treatment facility to deal with its own special wastes and a little landfill for the treated residues would be madness. The costs of duplication and the loss of economies of scale would be stupendous, and the problems of policing literally thousands of treatment plants would be completely unmanageable.

The next option advocated by many people is the so-called 4-Rs: reduction, recycling, recovery, and re-use. I have said that about 8 to 10 per cent of Ontario's wastes are now recycled; clearly, with deliberate attention and effort, this total could be increased. We can, and should, for example, develop explicit incentives to encourage more of the 4-Rs: faster write-offs on recycling equipment, for example, or removing tax disadvantages for recycled resources (the taxes on recycled oil, for example, are higher than for virgin oil). OWMC itself has developed a number of programs to foster the 4-Rs: the Ontario Waste Exchange Program with the Ontario Research Foundation; playing a broker role to find funds for a pilot plant to assist an industry with a new and promising waste-recovery technology; hiring technical staff to go out to plants and assist industry with waste reduction innovations; and so on.

However, no matter what is done to foster and encourage the 4-Rs, there is a limit to what can be done, and there will always be large amounts of wastes remaining that require treatment and disposal.

There is a misunderstanding about recycling that also should be set to rest. Recycling is not a magical panacea: it does not somehow make wastes disappear. Most recycling processes themselves have waste residues, often more concentrated and more hazardous than the original wastes and these require treatment in turn, and safe disposal. Recycling, then, is not a substitute for final treatment and disposal, but simply another, albeit very sensible, way of getting to the end point.

The next systems option is to leave it to the private-sector treatment industry to develop the facilities required to properly handle and dispose of these wastes. There are a number of reasons why this is not practical, and the fact stands that in our free market system the private sector has not, on its own initiative, met the need to this point. Throughout the 1970s the provincial government, a Conservative government, tried very hard to encourage the private sector to build modern hazardous-waste treatment facilities and, by its own admission, failed. Each attempt foundered because of strong public opposition, the high costs of public hearings and approvals, the reluctance of the selective private sector to provide full treatment services, the high capital cost of modern treatment technology – and, frankly, at times the lack of political will. The result is that there is just one major private-sector waste treater in Ontario: Tricil, in Sarnia, with good but limited facilities for organic wastes (30 per cent of the total generated in Ontario) and none at all for the inorganics (70 per cent of the total). Hence, in a spirit of frustration, in 1981 the government felt compelled to create a crown agency, OWMC, to deal with the problem.

A crown corporation, the fourth systems option, has a number of advantages over the private sector. Some of these may be seen as unfair, however real and practical: access to government funds, a greater likelihood of tough regulations reinforcing and expanding the market, political support, and the like. But two, in paticular, have real force: OWMC is required to provide a full service – to build and operate a system that will ensure that all the wastes in Ontario requiring modern treatment do, in fact, receive such treatment: we cannot pick and choose the profitable, easy-to-treat wastes and ignore the difficult, usually more toxic, wastes that require the greatest investment and operating costs. In other words, OWMC cannot skim the market, as the private sector understandably tends to do.

And second, OWMC is not subject to local by-laws. No community wants treatment facilities, and the usual approach to fending off private treaters is to pass a by-law preventing them from operating. Mississauga did this successfully in 1979 to prevent the burning of PCBs in a commercial cement kiln, a perfectly reasonable way of destroying these wastes.

Finally, we have to look to Western Europe for established models of the waste management system we are creating in Ontario, as there are none in North

America that provide the full array of treatment services. Some of the European systems – primarily in West Germany, Denmark, and Sweden – have been operating for as long as 15 years. All are publicly owned, though some have private sector investment as well.

In my mind I believe there is an analogy between the public sector development of toxic-waste treatment facilities today and our move 60 years ago from an outhouse or septic tank in each yard to the development of centralized sewage-treatment facilities to meet widespread societal need, or to the creation of Ontario Hydro at the beginning of this century.

Let me move now from my obvious preference for the public-sector systems option to the matter of the facilities options. We have a crown corporation, OWMC: what kind of facilities is it going to create? Parenthetically, no matter what our facilities design, eventually OWMC will have to have transfer stations around the province to facilitate the local collection of wastes. Remember the 16,000 industries, from Thunder Bay in the north, Sarnia and Windsor in the west, to Cornwall in the east.

The first question to be answered with respect to facilities options was: Is it better to have a number of facilities located in several places across the province, or one centralized major facility to start? We have opted for the latter, for a number of reasons: economies of scale, avoidance of the duplication of expensive equipment – a rotary kiln, for example, costs about $35 million; a laboratory for testing the wastes, about $2 million – the advantages of a single effluent and emissions monitoring system, and the desirability of imposing only one landfill on the province, for example. A very practical reason is that it would be almost impossible to handle the public opposition, hostility, and confrontation in several site communities at the same time. It is difficult to manage only one, let me tell you!

Having decided on the centralized facilities option, the next question to be answered was: What kind of treatment facilities will best serve the needs of the province? Early in its life, the OWMC Board of Directors made a number of important commitments: we would use only the world's best proven treatment technologies; only treated residues would be placed in landfill, after the best treatment, detoxification, and stabilitization this technology can provide; and we would apply the following criteria to the selection of our technologies: protection of human health; protection of the environment; and minimization of cost, consistent with the first two criteria.

With these commitments and criteria to guide us, we conducted a survey of more than 100 candidate treatment technologies around the world, sending our staff to Japan, many parts of the United States, and all countries in Western Europe. We were gratified to find that there is, indeed, a proven technology capable of treating each of the waste streams produced in Ontario. From these, we have selected the following major components:

- A *physical/chemical treatment plant*, housing a variety of technologies for treating inorganic wastes. These include technologies for neutralizing acids and caustics, for precipitating heavy metals, and for the chemical treatment of cyanides. There will be about 12 treatment process trains capable of dealing with the major inorganic waste streams produced in Ontario. The products of these will be filter cakes, sludges, and other solids and semi-solids, which will go to the solidification plant prior to deposition in the engineered landfill; and polished effluent water, which will be either recycled in the plant, itself solidified, or evaporated. The physical/chemical plant will have a 50,000-tonne/year initial capacity on a one-shift basis, rising to a 120,000-tonne capacity on a three-shift basis, as the market develops.

- A *rotary kiln*, operating at temperatures ranging from 1,000 °C to 1,200 °C for the incineration of organic waste streams. Kilns of the design planned can treat 30,000 tonnes of organic wastes per year and they can handle sludges and even waste-filled drums and contaminated equipment, such as transformers. They can also safely incinerate some of the more difficult wastes, such as the chlorinated hydrocarbons, with a destruction efficiency in the 99.99 per cent range. After the wastes are burned the combustion gases are treated by scrubbers and electrostatic precipitators before their release to the atmosphere.

There are no waste burning kilns of this type in Canada, and just a few in the United States. OWMC has engaged Von Roll of Zurich as our incinerator consultant, a firm that has designed and built a large number of such kilns around the world. Rotary kilns for destroying organic wastes are common in Western Europe, often in a twinned configuration.

The waste residues from the kiln are slag, ash, and used scrubber water, which will be recycled and finally evaporated or solidified.

- A *solidification plant* that will treat all of the residues from the physical/chemical plant and the incinerator, and at least some of the effluent water, with cement and other reagents. The solidified product, with very low leachability, will then be deposited in the engineered landfill.

- The *engineered landfill* will be located in deep, impermeable clay to provide a second, natural level of containment beyond that provided by liners and leachate collection systems. It will be fully monitored, and any leachate from the cells will be returned for further treatment, if this is required. The landfill will require about 250 acres, including a buffer zone, for a lifetime in excess of 20 years at an eventual 300,000-tonne treatment capacity (about 40 years at the initial 150,000-tonne capacity).

The common misconception of a landfill is a raw hole in the ground into which untreated, liquid hazardous wastes are dumped. As I mentioned earlier, one of OWMC's earliest commitments was that our landfill would be fully engineered and monitored, located in deep, impermeable clay, and it would be used for depositing only fully treated waste residues.

One of the most important components of an effective treatment system is a modern laboratory. Wastes are carefully identified before they are accepted from a generator. The identity of each shipment is then "fingerprinted," or verified against the original analysis, before each shipment is accepted for treatment. This ensures that each waste shipment receives the treatment it requires, that incompatible wastes are not mixed together in storage tanks, and that unknown contaminants that will inhibit effective treatment are not present in the shipment.

The capital cost of this facility, including the physical/chemical and solidification plants, the rotary kiln, the landfill, the laboratory, and all other components such as storage tanks, an evaporator, truck washing facilities, and the office complex, was estimated at about $100 million in 1981 dollars and is now estimated at about $150 million in 1985 dollars. Monenco (Ontario) Ltd. of St. Catharines has been selected as OWMC's primary engineering consultant. Together with OWMC's own engineers, Monenco has now completed the detailed conceptual engineering for our facilities.

Another option that has been proposed many times is that of developing mobile treatment facilities. This would avoid the necessity of fixed facilities being imposed on some unwilling community for a long period of time. OWMC has considered this very carefully, and we have concluded that mobile facilities for the treatment of some special wastes may well be a feature of our system at some time, but they will always be adjuncts to, rather than substitutes for, the central facilities. There are many drawbacks to reliance on a mobile treatment system: remember, there are about 16,000 waste-producing industrial plants, and the complexity involved would be enormous; economies of scale and a unified management system would be sacrificed; there would also have to be a multitude of laboratory testing units; opportunities for bulking and mixing would be lost; effluents would of necessity have to be discharged locally without the opportunity for evaporation and solidification; and treatment residues would still require disposal in an engineered landfill. The notion of Ontario being dotted with little landfills here and there, each fully engineered, monitored, and closely supervised, borders on the absurd. Finally, there are no mobile facilities that can deal with the full array of wastes that fall within OWMC's mandate.

Site Selection

These, then, are the facilities options that we have selected after reviewing and assessing more than 100 technologies around the world. Let me turn now to the most difficult and controversial aspect of our work – that of site selection, of finding a site on which to locate these treatment facilities. It is an understatement to say that no one wants such a facility in their own community: people are apparently ready to accept the most frightful polluting industries in their neighbourhoods but want nothing to do with a modern waste-treatment plant that, when all is said and done, would be similar to a medium-sized industry, operated to standards that will be the most rigorous in Ontario. The public perception, nevertheless, is of another Love Canal, another Bhopal, or another Mississauga chlorine spill. Love Canal, of course, was a hole in the ground into which untreated toxic wastes were dumped and on which, to compound the error, a subdivision was built after the dump was closed. Bhopal, Mississauga, and other sensational events involved not hazardous wastes but toxic industrial products – quite a different (and much more dangerous) thing.

OWMC's search for a site began early in 1982, after we rejected the site chosen by the government in South Cayuga because of its inadequate hydrogeology. We began with all of Ontario but quickly rejected the north because of inadequate environmental safeguards; because Precambrian rock does not provide the natural security of deep clay; and because of the risks and costs of long transportation hauls from southern Ontario, where most wastes are generated.

After surveying the hydrogeology of all of southern Ontario, OWMC decided to further concentrate its search on the Golden Horseshoe, around the western end of Lake Ontario, because we were assured by our consultants that we could find the suitable hydrogeological conditions we required in this area, and because 70 per cent of Ontario's wastes are generated in this area – by far the most industrialized in the province. Our search narrowed in 1983 to 20 broad general areas within the Golden Horseshoe, to 152 possible sites in those areas, and then to eight candidate sites announced in 1984; one in Mississauga, three in Milton, two in West Lincoln, and two in Niagara Falls. In May 1985, we eliminated the Mississauga site because its hydrogeology failed to meet our rigorous standards: this was after we had conducted drilling tests on all eight candidate sites. This fall, after further intensive study, we selected from among the remaining seven sites our preferred site, on which our efforts will now concentrate – one of the sites in West Lincoln.

OWMC has without question conducted the most extensive and intensive site-selection program ever undertaken on this continent, perhaps anywhere. The cost of site selection was about $11 million over three and a half years and more than 150 factors and indicators were used, including the following: hydrogeology, atmospherics, sensitive ecosystems and rare species, archaeology, transportation, agricultural soil and sensitive crops, tourism, municipal finance and emergency services, number of residents, family composition and stability, proximity to schools, hospitals, community centres, subdivisions, shopping centres, churches and graveyards, flooding, proximity to rivers and streams, risk analysis, and many more. In total, we have more than 40 voluminous reports on the analyses of these factors alone and their incorporation in an extremely comprehensive Environmental Impact Assessment - one of the most comprehensive ever.

At its inception, the government exempted OWMC from the provisions of the Environmental Assessment Act, though it did undertake to subject our work on site selection and facilities design to full public hearings. Despite this exemption, OWMC adopted the broad and good definition of the environment included in the Act, and we conducted our environmental assessments as if we were subject to the Act. This foresight paid off when, last July, the new government, with my full support, removed this exemption and placed OWMC fully under the Act, which in my opinion is a model of its kind. This at least removed one of the clouds of controversy that has surrounded OWMC in its site selection work.

Many factors played an exclusionary role in reducing our search from all of Ontario to a single preferred site, and many difficult tradeoffs were made: it was clear from the start that there is no "perfect" site for waste-treatment facilities. In an extensive, open process of consultation not only with local residents and councils but with many broader interest groups, industry, and interested individuals throughout the province, we had to grapple with questions such as: is good transportation access more important than existing air quality? Is it better to intrude on a stable agricultural community or on an area already scheduled for development? Should the very best hydrogeology be outweighed by shorter transportation routes? And so on. Literally dozens of such trade-offs had to be resolved. In the final analysis, OWMC gave slightly greater weight to the risk factors relating to safety and human health than to impact factors relating to socioeconomic and community considerations. Our first priority has always been safety. Nevertheless, socioeconomic and many other factors played strong roles in steering us from the 152 possible sites to the eight, and then seven, candidate sites, and finally to our preferred site.

With respect to public consultation, the OWMC staff and our consultants have met on over 2,000 occasions with members of the public in the last three years, from large (mostly unfriendly) public meetings of 800 or more to workshops and meetings with community interest groups in church halls and living rooms. Each of the families living on the eight candidate sites and immediately adjoining them was interviewed, if they were willing, and the residents along the access roads and within two kilometres of the sites received a questionnaire and a toll-free number to call for further information. These efforts to communicate, of course, will continue with the preferred site, and its community and OWMC will open a local information office this fall.

I now want to say a few words about the so-called NIMBY syndrome – the "not-in-my-backyard" syndrome. As I have said, almost no one wants OWMC's treatment facilities in their community, and this has come to be known as NIMBY.

NIMBY, of course, is a very widely known aspect of human behaviour, whether expressed as opposition to a new highway, a new airport, a hydro right-of-way, or a group home in your neighbourhood. However, with toxic-waste treatment plants it reaches its most acute form: not only are people opposed to anything that will disturb them, but they become almost hysterical at the fear of being poisoned. However irrational – in the sense that each of us, daily, is exposed to much greater risks than could possibly be created by OWMC's activities, including untreated toxic wastes in each of our "backyards" – this fear is nonetheless very real, and it can only be overcome by understanding the nature of the problem we already face with untreated wastes and of the capabilities and safety of OWMC's facilities. Just as one of many examples, our risk analysts have calculated a worst-case scenario for the air emissions from OWMC's rotary kiln: If all emissions were of the worst possible nature at the highest possible concentrations, a person who spent 24 hours of every day at the plant boundary or the point of maximum impingement for 30 years would run a risk of one in one million of getting cancer from this source. Put another way, 250,000 of each one million Canadians will contract some form of cancer during their lifetimes. With OWMC's facilities in operation, the maximum increase would be to 250,001.

Nevertheless, NIMBY cannot be taken care of by such simple statistics. It will take a long and intensive program of public education and, even then, will inevitably be only partly successful.

There are really at least three major components of NIMBY as we see it:

First, there is a general widespread opposition to any development that is perceived to be a disturbance of the status quo, coupled with particularly acute opposition to, and suspicion of, any government initiative: the government is always wrong and always trying to hassle the people, usually in lying and deceitful ways. We can only hope to deal with this by continuing to be open and approachable in our programs.

Second, there is the deep-rooted fear of toxic substances and unknown technologies. This can only be met by making people more familiar with the nature of the problem, with simple elements of toxicology, and with the design and operations of the facilities themselves. We plan to take groups of local residents to Europe to see the facilities there for themselves, for example.

And third, there are pocket-book concerns: people fear that their property values will fall if OWMC moves into the neighbourhood, that they won't be able to sell their homes, that OWMC will be a burden on municipal finances, and that taxes will rise accordingly. I'm going to return to this aspect of NIMBY later on.

NIMBY expresses itself in many ways, some very positive and mature. Many people, for example, are hungry for information and for technical details. Others want to hire their own independent technical experts to review our work on site selection and facilities design, and we have provided funds for them to do this. Still others give enormous amounts of their time to becoming informed and to forming community groups to study the issues, prepare briefs (many of exceptionally high quality), hold discussions with our consultants and staff, and generally to monitor and invigilate OWMC's work. They do not conceal their opposition to our facilities being in their communities but rather try to oppose us on an informed, rational basis. This I welcome, and I have come to be an even greater admirer of the citizens of this province than I was before taking on this job.

However, there are a few of our opponents whom I do not respect. Some, for example, choose to deny the need for modern treatment facilities, apparently preferring the status quo to facilities placed in their backyards. Others have invited entire classes of primary school children to write, expressing the fear that they will not be able to have children because OWMC will poison them all to death or sterilize them. Such tactics, based on no matter what ignorance or opposition, are contemptible.

Another common attitude is to acknowledge that there is a serious hazardous-waste problem but to deny any personal responsibility. "I did not create these wastes," some people say, "and therefore the treatment facilities should not be located in my community." This denial overlooks the fact that each of us is a consumer. We want the products of industry, in the production of which wastes are produced. As I have said, this is not a matter of guilt, but, most emphatically, it requires us to recognize, each of us together with industry, a shared responsibility to ensure that these wastes are taken care of properly.

Setting these abberations aside, it is gratifying that, by far, the overwhelming majority of people in Ontario (and we have consulted many thousands) recognize the urgent need for toxic-waste treatment and want OWMC to get on with the job. Given that we must have these facilities, it follows that they must be located somewhere, at the inconvenience and over the opposition of some community.

The Operations of a Waste Treatment Plant

Let me turn now to the operations of the plant once it is established and to business development. First, there is a very positive side to OWMC in the form of benefits and compensation that we will bring to the community. During construction, there will be a total of 1.1 million person-hours of employment, more than 600 jobs at the peak period. The plant itself will employ about 120 people to start, rising to about 220 when and if the 300,000-tonne capacity is reached in the tenth year. Our annual operating expenses, exclusive of salaries and debt servicing, will be about $22 million, and much of this will be spent locally. There will be grants in lieu of taxes and other forms of payment to the host municipality. OWMC will pay the costs of providing services to its plant, both capital and operating, and we will pay for things such as access route realignments and road upgrading, if required. In short, OWMC is committed to paying its own way in the community in which its plant will be located.

In addition, of course, the usual expropriation provisions will apply to the landowners actually resident on the site. In Ontario these provisions are quite generous, and OWMC is developing policies that will protect the land and residence value of neighbouring properties.

With respect to the overall costs of operating OWMC's facilities, naturally we will charge our industry customers for our services. Our objective eventually is to run a break-even operation where our income matches our costs. We estimate that our total operating costs at the 150,000-tonne capacity will be approximately $27 million per year, but there remain several major unknowns at present: the government's requirements with respect to repayment of capital; and whether the effluent water from the plant will be totally solidified and deposited in the landfill, or whether some of it will be evaporated, using auxiliary evaporators in addition to the waste heat from the kiln. Certain options with respect to these two matters have substantial cost implications.

Given OWMC's break-even objective, our approach to pricing is the flipside of estimating our operating costs. Setting aside the costs of transporting the wastes from the generator to OWMC's plant, which will be borne by the generator and paid to the transportation companies on which we will rely (OWMC does not intend to enter the transportation business as long as our needs and those of our customers can be met by the private sector), our prices will be very treatment-dependent. The treatment costs for some wastes are very high – perhaps as high as $1,000 per tonne – and for others they will be quite low. Generally speaking, high-volume, low-toxicity wastes are cheaper to treat than low-volume, high-toxicity wastes. On average, using price estimates both from elsewhere in North America and from the extensive European experience, we believe our average price will be in the neighbourhood of $150-$300 per tonne. At a capacity of 150,000 tonnes per year, this would yield an annual income of about $25-$30 million, very close to our estimate of annual operating costs. Transportation costs, at approximately 18¢ per tonne/mile, would be an additional cost to the generators.

Perhaps one inevitably thinks in terms of price lists for OWMC's services, as in a supermarket. And, indeed, our prices will require government approval. However, the general experience in the waste-treating industry is that there are no lists per se: as new customers present themselves or are sought out by OWMC, a detailed analysis will be made of the wastes they generate. This analysis will be used by OWMC to determine the exact treatment process required and the cost of this treatment. That information will then be used to establish a treatment price quotation for the customer. Once the contract is signed, the price holds, subject to periodic review, as long as the waste shipments from that customer are confirmed by laboratory fingerprinting to be what they are claimed to be.

A widely expressed concern has to do with the impact that this additional cost for waste treatment will have on industry in the province. There are several replies: these costs will be spread among several thousand generators; it is preferable to having each industry being required to tie up capital and commit operating funds to its own, in-plant waste-treatment facilities; at least there is no profit component to the price; and so on. Regardless of all this, the bottom line is that hazardous waste treatment is a *sine qua non* for doing business in a modern, industrialized society; there is no other alternative. Presumably, these new costs to the generating industries will be passed on to those who buy their goods and services; that is the cost of being a consumer in a modern, industrialized society.

The claim that "industry must pay" for the costs of waste treatment is a political slogan, and one to which I personally subscribe. We all know who pays ultimately – namely, the consumer, under the model I have outlined, and that is the way it should be. Another model, which I do not advocate, would be for OWMC to offer its services free. In this case there would be no financial incentives to industry to do more in-plant waste reduction and to recycle, and the taxpayer (i.e., the consumer) would end up paying in any case. The market model that we propose and that the government suggests has far more discipline and accountability than any other we can imagine.

Parenthetically, I can mention that although OWMC may appear to have a financial advantage over the private sector in that it has no shareholders expecting a return on their investment, this advantage may be more fancied than real. OWMC's commitment, as demanded by a sensitive and concerned public, is to the best of everything and to remaining at the very forefront of proven technology. OWMC, for a time, will have the world's best treatment plant; that is our commitment and the government's commitment. And that costs money – a lot of money.

Understanding the Market

OWMC has put a great deal of effort into developing its understanding of the market for hazardous waste treatment in Ontario over the last three years, through the efforts of our Director of Marketing, his staff, and consultants. In addition to identifying the 16,000 plus generators of such waste in this province, more than 1,000 have actually been interviewed personally at the plant level to enable us to sharpen our estimates of waste quantities and characteristics and to learn as much as we can about their production processes and their problems of waste disposal. This is, without question, the most extensive waste survey of its kind ever conducted anywhere, and an invaluable base on which to develop our market when our plant is in operation.

Moreover, we have hired professional staff to work directly with plant managers and operators in fostering waste reduction at source. Why pay to have waste treated when, by process redesign or some other simple, inexpensive modification, the amount of waste produced can be reduced substantially? Our staff already have reached out to several hundred industries to offer this assistance and will reach out to thousands more. This, too, also pays off for OWMC in building our knowledge of the waste market.

Finally, to assist us in gaining as full an understanding of the waste market as far in advance of going into operations as possible, OWMC has entered into a joint venture with a private analytical laboratory. The purpose of this initiative is not only to give us more real world experience with the wastes actually being generated in the province but also to give our laboratory technical and supervisory staff hands-on experience with the problems and challenges of precision analysis of real wastes. As an added plus, in the aftermath of the proclamation of provincial Regulation 309 under the Environmental Protection Act, which requires that hazardous waste generators provide the authorities with detailed analyses of their wastes, this initiative gives OWMC the first opportunity to provide a technical service to our customers of the future.

I must point out at this stage, however, that despite these efforts to learn as much as we can about the waste market, several major uncertainties remain until we are in operation and actually begin to enter into contracts with waste generators and to receive shipments from them.

First and foremost is uncertainty about the degree to which regulations will be tightened when OWMC's treatment facilities come on stream. OWMC is not a policeman or a regulator; that responsibility rests with government, specifically with the Ministry of the Environment. At present, simply because there is no realistic alternative, certain unsatisfactory waste disposal practices are permitted, such as sewering and disposal in unsuitable landfills. When OWMC's facilities are available to provide proper and effective treatment, these practices must be cut off. If they are not, OWMC will find itself attempting to charge a fee for waste treatment that is far in excess of "free" or low-cost (however unsatisfactory) alternatives. At an average cost of, say, $250 per tonne, OWMC cannot compete with an $18-per-tonne fee for disposing of untreated wastes in a cheap landfill. This is the problem that defeated Genstar in British Columbia and that has caused problems for Stablex in Quebec. The lesson we have learned above all from the European operations is that, if tightened regulations do not require the movement of wastes to the treatment plant, there is no way it can become a viable financial operation.

Second, we have no way of determining at this stage what impact tightened regulations and the costs of proper waste treatment will have on the wastes generated by thousands of individual entrepreneurs. Some undoubtedly will find it financially advantageous to put some capital into their own in-plant treatment equipment, into waste reduction technology, or into increased efforts at recycling. Most likely of all is that many companies will begin to dewater their wastes (many special wastes have very high water contents) to avoid paying $250 per tonne to have water treated by OWMC. The net effect of the sum of these individual financial decisions and cost-benefit analyses will be to reduce the amount of special waste coming to OWMC, but we do not know by how much. That is the major reason why we have designed our plant for a rather modest opening capacity of 150,000 tonnes per year (about 20 per cent of our estimate of the special wastes not now receiving some form of treatment), with provision for modular expansion to 300,000 tonnes per year in the tenth year of operations if experience justifies this development.

The second most important lesson we have learned from the European operators is that, no matter how many market estimates are made beforehand and no matter how precisely you calculate the above impacts, you will not really know what wastes you will receive and in what quantities until the day you open your gates and begin to receive shipments.

I would like to point out very clearly at this point that despite the foregoing comments on the costs to industry, in general industry is among OWMC's strongest supporters. Industry realizes that hazardous wastes must be treated properly in a modern society and that such treatment will have its costs. Many industry representatives simply tell us to get on with the job of bringing our facilities into operation as quickly as possible and to make sure that they are the best and most appropriate for Ontario's particular wastes.

One final comment about OWMC's status as a crown agency: I am frequently asked what will our competitive stance be with respect to the private-sector waste-treating industry? The question is a little more simple in Ontario than it otherwise might be because, as I have mentioned, there is only one major treater in Ontario – Tricil in Sarnia. Tricil has no treatment facilities for inorganic wastes (70 per cent of the total); in addition, its liquid injection kiln can only handle liquid organic wastes and is not permitted to incinerate wastes with a chlorine content greater than 2 per cent. It is fair to state that OWMC's facilities will be able to treat all of the wastes that Tricil treats and many more besides. Nevertheless, Tricil has a good operation, and OWMC has no desire to compete with them head on; we certainly do not want to put them out of business. We may well compete with Tricil and others for certain desirable wastes, such as those with high BTU values to reduce the need for virgin fuel in the incinerator, but as fuel values rise this competition in the industry will become very aggressive regardless; OWMC will simply become one more among the competitors.

It is also fair to say that OWMC and the treatment industries have not yet turned their collective attention sufficiently to the possibilities of further joint ventures between OWMC and the private sector. I hope this will come in time but at the moment, and until our facilities are approved, OWMC really has no cards with which to enter the joint-venture game. I hope that day will come, because I personally believe that there are great merits and benefits in the concept of joint ventures between crown agencies and the private sector. In that direction could lie the best of two worlds.

Conclusion

In conclusion, I would like to say a few words about OWMC's timetable and the future. We have taken three and a half years to identify our preferred site and complete the conceptual design for our treatment plant. I make no apology for this: 10 years is the norm for major projects such as this. Alberta took 10 years alone to find a site for its treatment facilities, and without the requirements for public hearings. The Regional Municipality of Halton, west of Toronto, has taken 12 years to find a site for a new municipal landfill, and they have not yet succeeded. New highways in this province require about 10 years from inception to routing approvals. The record is clear, and there are strong advantages to "taking the time to do it right," a commitment we have had since our rejection of the South Cayuga site in November 1981.

Last September, we announced our preferred site. We are now studying this site at an even greater level of detail: drilling up to 40 boreholes and installing instruments to measure water movement in the clay (measured in terms of fractions of centimeters per year); installing monitoring equipment to determine atmospheric conditions; conducting ecological and archeological surveys; and refining our information on a host of socioeconomic factors. This work will be completed in 1986 or early 1987, and we will then forward our submission to the Minister of the Environment. It will be a massive submission, documenting all of the work we have done and including as many as 70 or 80 very bulky reports from the wide array of consultants we have used. The Minister will solicit reviews of our submission from the many other government departments and agencies with an interest in our work – Health, Transportation and Communications, Industry and Trade, Agriculture, and the like.

When these reviews have been completed, our submission will go to the Environmental Assessment Board of Ontario, which will hold extensive public hearings on our proposal. There will be a multitude of intervenors, some hopefully supporting us, but many strongly opposed. There will be witness discovery, interrogatories, witness stands, and aggressive cross-examination. There will be legal appeals, some perhaps going all the way to the Supreme Court of Canada. No one can guess how long these hearings will take: lawyers generally estimate from one to two years. When approval of our proposal finally is obtained from the Board (assuming that it is!), with or without conditions, the provincial Cabinet has 28 days in which to vary the decision and/or to consider final appeals. After this, the land for the facilities must be purchased or expropriated – and then, and only then, can OWMC proceed to construct its treatment plant and enter the business of waste treatment. The plant itself can be built in about 20 months. This process may seem to be extremely time-consuming and exasperating to the uninitiated, but it is the law of the land, and it is a law I strongly endorse. In an area as sensitive as toxic waste treatment, surrounded as it is by public concern, even hysteria, and strong local opposition, no other process will win OWMC the credibility and confidence it must have to meet the needs of the province effectively.

I have tried in my remarks today to give you some insights into the problem of toxic industrial wastes. It is an exceedingly complex problem, reflecting in itself almost every conceivable element of the complex society in which we live. It is, however, a problem for which there is a good solution; that is perhaps the most satisfying thing I have learned in my nearly five years as head of OWMC. Industrial wastes are the product of modern, industrialized society, and every such society must accept its responsibility to treat them right.

Comments by Irving K. Fox (abridged)

> While any new technical device may increase the range of human freedom, it does so only if the human beneficiaries are at liberty to accept it, to modify it, or to reject it: to use it where and when and how it suits their own purposes, in quantities that conform to those purposes.[1]

Before commenting briefly on Dr. Chant's paper, I will define the nature of the toxic-substance management problem as I perceive it, and then suggest some principles for dealing with it. This will provide the basis for my discussion of Dr. Chant's paper.

Toxic substances that affect the environment may be categorized in the following way: first, those toxic materials which have already been discharged into the environment and which pose a hazard to people and life-support systems; second, those toxic industrial wastes which are currently being produced – e.g., discharges from smoke stacks, automotive exhausts, and liquid and solid materials left over from industrial processes (Dr. Chant's paper deals with the solid- and semisolid-waste component of this category); third, those toxic materials which are intended for direct application to the environment (e.g., pesticides); fourth, those toxic materials which are incorporated into consumer products (e.g., automobiles, household equipment, etc.) and which will eventually be discharged as wastes.

Toxic substances have ramifications for the economy, for public health, and for the viability of ecosystems. The benefits that we derive from the use of toxic materials are offset by some substantial social costs, but I know of no effort in Canada to arrive at a total estimate. It is instructive to note that a 1985 report of a California state agency states that "coping with toxic chemicals may very well cost Californians over $40 billion during the next decade."[2] This same report estimates that each year 2,500 Californians die of cancer "resulting from exposure to toxic chemicals." Quite apart from any economic and public health costs that can be approximated, there remain other health costs and effects on ecosystems that are very difficult to measure.

Public management decisions in which benefits and costs must be weighed are made, therefore, a) in deciding how much to invest and what measures to adopt in order to clean up past toxic waste discharges (California estimates that this task will cost $11 billion in that state); b) in determining whether a new material should be allowed on the market in view of established or possible toxic qualities, and in designating those materials that should be regarded as hazardous; c) in determining what toxic industrial wastes will be produced and how to dispose of them; and d) in regulating the use of toxic materials that are marketed.

In approaching these decision-making tasks, I will make an important assumption – namely, that the principle of "consumer sovereignty" should govern. That is to say, those affected should determine whether the benefits justify the costs. This is a basic principle of neoclassical economics, and it is akin to the basic principles of democratic political theory. I believe that this principle must be fully applied if we are to deal with toxic substances effectively.

In applying this principle of consumer sovereignty to our decision-making tasks for toxic substances, we face a number of difficulties. One of these is the uncertainty associated with the management of toxic substances. David Suzuki has said that he had reached "the disturbing conclusion that it is impossible to predict the consequences of technology."[3] This comment applies with a vengeance to toxic substances. Also, the market does not function effectively, for a variety of reasons. Use of common property resources, the production of public goods and "bads," and the difficulties consumers face in becoming fully informed about the consequences of various types of fabricated products make it impossible for the market to reflect faithfully public preferences and priorities.

Probably of far greater importance than either uncertainties or market failure are certain features of our culture and the kind of governmental processes we have devised for managing toxic substances. In our culture there is a widely held assumption that a quantitative increase in material goods is the highest goal of society.

The high status of science and technology, combined with the association of new technologies with profits and increased material output, seriously dampens any effort to control the production and use of toxic-substances so as to reflect human values. In general, these perceptions have caused toxic-substance management to be regarded as a technical and scientific matter, too complex for the public to understand. The result has been that decisions governing the production, use, and disposal of toxic substances have been dominated by the producing industries and by career government personnel.

It is not possible, in this paper, to describe in detail the decision processes for managing toxic materials in Canada. A recent paper characterizes the process followed in Canada as follows:

> Together, the industry scientist and the bureaucrat decide what information and testing is necessary to demonstrate the safety and effectiveness of each new [pesticide] product.[4]

In these processes, academics (usually scientists who may or may not have a special proficiency in the assessment of human values) may serve on advisory committees. Only if an issue becomes "politicized" (which is very infrequent, considering the number of substances involved) do ministers and interested members of the public become involved.

If these processes do, in fact, accurately reflect public preferences and priorities, it will be by coincidence. The literature on interest-group and bureaucratic behaviour has clearly demonstrated that these groups have their own perceptions of problems and their own preferences and priorities. Furthermore, producer representatives and career government personnel are particularly ill-suited to dealing with the problem of responding to the unforeseen physical, biological, and social consequences of a prior decision. They have a vested interest – in part psychological and, possibly, in part material – in maintaining the validity of the original decision. In making this comment, there is no intent to impugn the sincerity of government personnel or industrial representatives. They perceive issues and solutions in a manner quite consistent with our understanding of human behaviour. Nevertheless, we cannot consider the decision processes now generally followed to be consistent with the principles of democratic government.

Not all members of society share such a bias in favour of increases in quantitative output, and I suspect the bias is more strongly held by those who produce toxic materials than by a number of other social groups. There is, I believe, good reason to expect that, with more democratic processes, toxic material management would involve much more careful weighing of the social consequences of such substances than is now the case. From an ethical point of view, if risks are to be taken with toxic substances, those affected should be involved in making such a decision.

The question, then, is: What should be done about public decision-making arrangements in order to assure that the principle of consumer sovereignty is applied to toxic substances?

One response might be to employ a system of taxes or charges that reflect the costs that toxic substances impose on society. For about 25 years economists have been proposing that waste producers bear the costs that their wastes impose on others. I think this is an important principle and should be applied to the extent that costs can be ascertained or even approximated.

While this idea has been around a long time and while there have been a number of instances where it has been applied successfully, it has not been widely adopted. Failure to use a charge system may be attributed in part to misconceptions (such as the view that a producer can buy a right to pollute). My judgment is that charges are not imposed on waste dischargers primarily because of the political influence of waste producers. In other words, even a relatively simple change to reflect public preferences (such as the decision to use charges) cannot be achieved without overhauling our processes of public decision making as applied to waste management.

Existing public decision processes should be changed in a way that emphasizes democratic principles. There is no space to delineate my suggestions here, but the key role of career government employees would come to an end. The fact that public decisions involve a bargaining process would be recognized and legitimized. A genuine effort would be made to involve the full range of interests on an equal basis in all benchmark decisions relating to the production, use, and disposal of toxic substances without resorting to public hearings in all cases.

How does this relate to the Ontario Waste Management Corporation (OWMC) and its activities, as described in Dr. Chant's paper?

First, let me say that I applaud the work that Dr. Chant and his colleagues have done. In a number of respects they have laid a strong foundation for the effective management of the toxic industrial wastes that are currently being produced. Through the extensive use of public hearings with funding of intervenors, the officials of OWMC should have a good understanding of the kind of program that is needed, to accord with a reasonable balancing of public preferences and priorities. The performance of OWMC to date certainly commands admiration.

However, I have some basic reservations about the implicit assumptions underlying the approach followed by OWMC to date and about the use of a conventional type of crown corporation to manage toxic wastes in the future.

Briefly, the discussion of the NIMBY (not-in-my-backyard) syndrome in Dr. Chant's paper reveals the cultural bias that I described earlier and does not adequately reflect the cost of locating a waste-treatment operation. Furthermore, by not attributing any costs to facility location (except the value of the property being used or affected), OWMC will be subsidizing – and thereby encouraging – the production of toxic wastes.

It is doubteful that a crown corporation directed and staffed in the conventional style is an appropriate institutional arrangement for implementing the kind of program OWMC has devised. There has been widespread concern about the accountability of crown corporations. Ways have been proposed for improving legislative oversight of these organizations, but I simply do not believe that legislators have the time to provide effective control, except where a dramatic issue arises that commands widespread public attention. It appears to me that difficulties have been more acute where the crown corporation has held a monopoly over the provision of a particular type of service. This is not to suggest that crown corporations cannot be effective instruments of public policy, but it does suggest that we must give careful thought to how such entities can be designed to reflect faithfully public preferences and priorities.

One must also recognize that the proposed program described by Dr. Chant will not resolve all of the value questions that OWMC must face as it implements its program. For example, there is the question of the prices to be charged for its services. Unless some specific provision is made to include a range of interests in this negotiating process, experience suggests that the organizational interests of OWMC and the interests of waste producers will result in treatment and disposal costs being highly subsidized by government, and the prices of products responsible for toxic wastes will not reflect the full costs of disposal.

One final point needs to be emphasized: OWMC would only be responsible for part of the task of hazardous-waste management in Ontario. It would not be responsible for cleaning up the estimated 2,000 dumps of concern in Ontario. It would not decide whether a new material should be allowed on the market, nor, if a given material is deemed hazardous, how its use and disposal should be regulated. Decisions that determine what wastes must be handled by OWMC would be outside its domain. I do not believe that OWMC should have these responsibilities, but we must recognize that they are critical components of a system of hazardous waste management. It is because of past failures in regulating the production, use, and disposal of toxic substances that so many hazardous dumps exist in Ontario. The literature indicates that these activities are dominated by waste producers and career government personnel. My view is that unless these activities are more democratically administered, Ontario cannot have a fully effective hazardous-waste management system, even if OWMC performs its part of the job in an exemplary fashion.

While my rhetoric may sound confident, I do not believe that anyone has a fully satisfactory answer to the design of decision-making arrangements for managing toxic substances. Decision-making processes are a neglected aspect of all sectors of environmental management. We have tended to take for granted certain features of governmental decision-making processes that have grown out of the parliamentary system, as though they were dictated by God. Some of these features frustrate the application of democratic principles and the reflection of important human values. This is an area which deserves top priority in future research. In fact, I will be so foolhardy as to predict that, if the amount invested in physical, biological, and economic research related to the management of toxic substances were cut in half and the savings were invested in research and experimentation aimed at improving decision processes for managing toxic substances, the net benefits from the use of such materials would soon be doubled. In conclusion, I commend to you a sobering comment by Mumford:

> One must be ready to go forward at a slower pace, looking before and after; to make fewer discoveries, to spend as much time assimilating knowledge as in acquiring it; to do less, perhaps, in a whole lifetime in any one department than the concentrated specialist is able to do in a decade. From the standpoint of the power system this demands an impossible sacrifice: the sacrifice of power to life.[5]

Comments by Pierre Grenier

I share with Dr. Chant a lot of frustration about the misconceptions of the public, the media, the government, and industry towards the real hazards of industrial waste and the need for a comprehensive waste-management system supported by the best available technologies.

A workshop like this one today is very useful to our industry inasmuch as it contributes to clarifying the issues, defining the problems, and proposing the right solutions. Over the past four years, OWMC has done a great job in Ontario and throughout Canada of informing the public, identifying the solutions, and promoting them.

I would like, however, to comment on some of the statements made by Dr. Chant and to express my views on what I perceive to be the real problems facing the waste-management industry.

I agree with Dr. Chant when he defines the threats that industrial waste represents to the environment and to humanity. I also support his choice of solutions. I believe that the scenario proposed to overcome public opposition will eventually succeed, and I am sure that OWMC will obtain all the necessary funds to build a centralized waste-treatment facility offering the best available technology.

I am not convinced, however, that Ontario's industry will use that facility simply because it exists. I question, also, the cost benefits of the public relations process that started four years ago and will last for another two to three years before the project becomes a reality. I also disagree strongly with Dr. Chant when he justifies the existence of OWMC by saying that the private sector is unable to come up with adequate solutions and to build treatment facilities using the best available technologies.

It is well known that a problem can only be solved when it is well identified and well defined. Unfortunately, there is a misconception of the problem by the public that makes the solutions more frightening than the problems. In some ways, all the publicity around OWMC's project contributes to amplifying that misconception.

The hazard that industrial wastes represent to the environment and human life is not in its toxicity but comes essentially from mismanagement, lack of control, and monitoring. The industrial wastes are no more toxic than the raw materials they come from which are used, handled, and transported without public opposition. In fact, they are usually less toxic and less harmful because they are more diluted. The real hazard comes from the carelessness of their elimination and their high mobility in the air and water.

Once that problem is properly recognized, the solution becomes clear. First, it requires a stringent law and an equally stringent enforcement of regulations to control the wild elimination or dispersion of waste to nature. Second, it requires good technologies to detoxify the waste and guarantee that their final disposal in the environment is safe today and will be safe tomorrow.

In the last 25 years, many laws and regulations have been enacted and enforced. Industry always adapted to them. The required technologies have been developed and implemented as they were needed to meet the standards set by the regulatory authorities.

The first regulations were aimed at a reduction of suspended toxic particles in atmospheric emissions. The air represents indeed the most direct and rapid carrier to bring a toxic particle from a point of emission to a point of absorption by living organism.

The second set of regulations concerned water pollution, water being the second only to air as the best carrier of toxic elements from the point of emission to the food chain.

So far, the industry has coped with all the regulations already enacted, but a few more are still needed. The question of acid rain, for example, is one of the key issues. The solutions are known, as are their cost. Their implementation is only waiting for the adequate pressures from the public and a political will to clean the environment.

But even if the problems of air and water effluents were adequately solved and all emissions well within acceptable standards, the problems of elimination would remain untouched. The air is usually cleaned with water, and water effluents are cleaned by filtration and concentration. But the toxic species are still there, albeit in a different form. Where do they end up? I will tell you: They end up in the soil, where they are as mobile and as toxic as they were in the air and the water.

What is needed today is a new set of regulations to control the final disposal of industrial waste.

I strongly believe, like OWMC, that this ultimate disposal cannot be done without treating the waste to either detoxify it totally or substantially reduce its mobility.

In his remarks, Dr. Chant described some of the technologies that are available and used in Europe and Canada to properly handle industrial wastes. I share his views on what an ideal centralized treatment centre should be. I think, however, that he is pushing a little too far when he proposes to either solidify or evaporate polished water-effluent streams.

I also believe that OWMC is pushing a little too far the public relations program in their search for a suitable site. All that effort, time, and money could have been spent more efficiently in setting up a facility. Local opposition can be overcome when properly addressed and when there is a consensus and a will to succeed that are shared by a promoter and by local and provincial politicians.

The importance and the budget allocated by OWMC to its public relations and consultation programs probably created more fear and more resistance, initially, than a lower-profile approach would have. Nevertheless, I believe that they will finally succeed; no one could argue with any certainty that a different approach would have failed or succeeded.

I disagree with Dr. Chant when he justifies the existence of OWMC by allegating that the private sector is unable to come up with the right solutions and treatment facilities using the best available technologies.

Stablex Canada Inc. has built an inorganic-waste treatment and solidification plant in Quebec. Tricil has built a liquid organic waste incinerator in Ontario. Many other companies and engineering firms are offering special services such as PCB decontamination and sludge filtration. Some generators have equipped themselves with chemical/physical treatment systems, biodegradation units, and so on. Dr. Chant himself recognizes that 750,000 tons are treated in Ontario and 150,000 are recycled by the private sector.

In spite of all the important contribution that OWMC is bringing to the development of the waste-management industry in Canada, I believe that in general, the crown corporations are created when there is a lack of real political will to solve a problem and a lack of determination to put in place the regulating mechanisms that are needed.

The waste management industry only exists in a regulated environment. Whether the services are offered by a crown corporation or by the private sector, the level and quality of the services used by the generators only match the tightness of the regulations and the level of enforcement. The prices of those services will be set by the economic forces of the market. In the absence of regulations, only a crown corporation can offer a service that is not needed at a price that does not cover the full costs.

The private sector is currently offering the services that are needed by the generators. It is not because there exist facilities like the Stablex plant in Blainville, the plant planned by OWMC, or the one being built in Alberta by Chem Security, that the generators will use them. It is only when the services offered match the regulations that the facilities are used. Then price is not a significant factor.

I believe that the politicians are making mistakes in creating crown corporations without supporting them with the corresponding regulations. I strongly believe that if they take their responsibilities, and enact and enforce the proper regulations, the private sector will come up with the desired technologies, and the government will not have to spend so much of our tax money in a field where the dynamism of the private sector is more likely to succeed.

The question of price is often cited as the reason why the generators are not using the best available technologies. I have been told many times: "Reduce your price to increase your volume." That is wrong. The generators will use the services required by law at the price that has been set, or they will not use them at all. Cutting prices will not increase the profitability; it will only discourage the technical development.

The cost of treating waste has to become a cost of manufacturing the products that are wanted. Initially, it may seem to be more than the producers want to pay for, but some studies have shown that, on average, the cost of properly disposing of industrial wastes represents approximately 1 per cent of the total cost of manufactured goods.

With the proper regulated environment and enforcement, the cost of treating waste will become part of the manufacturing costs and an incentive to technological development. After two and a half years of experience in that field, I have already noticed that the generators using our so-called "expensive" services are generally not at an economic disadvantage. More often than not, they are the leaders in their fields. They use more advanced technologies, and they have a better control on their operation, a better knowledge of what they reject, and a better social awareness.

Subsidizing the waste-treatment industry in order to maintain low prices is a bad approach to stimulating the innovation and waste volume reduction that should be the aim of any government. I am not sure that a crown corporation would share the same views if the operator were subsidized on a per-ton basis.

Filling the plant will become the natural objective of the facility managers and if profits are of no concern, they will fill it up at any price with any waste. If the prices are low enough, the generators will not feel justified in investing in process improvements.

Do I believe in joint venture involving crown corporations, and the private sector? Yes, I do! I even see some advantages to doing it. A crown corporation has access to public funds; it can, more than the private sector, afford the cost of detailed market surveys and public relations programs; and it has enough credibility to put pressure on governments and to render the other establishments of a facility more acceptable to a designated community. On the other hand, the private sector is likely to supply a more efficient, more productive, and more competitive operation, at a lower cost to the taxpayer.

In closing, I would like to stress once more the importance of stringent regulations to achieve effective protection of the environment. The problem does not lie primarily with the toxicity of the wastes or with the lack of technologies to treat them; the problem is a question of mismanagement and that will only be corrected by laws, regulations, and enforcement, supported by the development of good treatment facilities.

Floor Discussion

Question: *On toxic waste disposal there seems to be general agreement that regulation and enforcement "run the machine." How do we know what facilities to design until we know the demand for disposal services, which may, in turn, prompt government to set regulations so as to assure the facilities are fully utilized?*

D. Chant: There is no perfect answer. An element of faith is required. But we do have a few rocks to stand on in this swampy terrain. An understanding is emerging of what we mean by hazardous waste and by special waste. Thus we are laying the ground work for setting regulations. And looking at other jurisdictions, we can see, for example, that soon the disposition into landfills of untreated organic wastes will stop in the United States. Such a regulatory change in Ontario by itself would guarantee that our rotary kiln would be fully utilized.

Question: *Dr. Chant's paper describes a horrific process of public consultation that must be gone through in order to set up the waste treatment facility, and still the necessary political approval may be withheld at the very end. Cannot OWMC analyse and deal with the psychology of the NIMBY (not-in-my-backyard) syndrome and turn it around?*

D. Chant: Now that OWMC has identified a preferred location in West Lincoln, we are trying to come to terms with local opposition. NIMBY is composed of many things. The corporation can deal, for example, with worries about property values. Similarly, we can alleviate concerns that the corporation will be a financial burden on the community. There is, however, a segment of NIMBY unamenable to reason. The approval process described in the paper is the law of the land and cannot be circumvented. In my opinion, such a process is desirable if we want to come to sensible and acceptable decisions. It should be noted that, so far, the creation of a facility in Ontario has enjoyed all-party support.

Comment: Perhaps we ought to reconsider the advice of economists such as Professor Baumol, who has suggested that government offer firms incentive prices to dispose of waste safely. He reasons that no penalty system will eliminate the "midnight dumpers," and he argues that if simultaneously a tax is imposed on waste, producer costs won't be seriously misallocated.

6 Dams and the Environment

Presentation by Camille Dagenais

Your Chairman first asked me to talk to you about international environmental issues and policies. That's a tall order. Even though I've had the opportunity to visit many countries, to work on large civil works and industrial projects in several of them, and to participate in many international scientific organizations, it would seem to me presumptuous to try to cover the whole subject.

So we at last agreed that I should talk about a subject I believe I do know something about – though I may be the only one to think so – the management of our resources of fresh water, and how it ties in with trying to serve the needs of our fellow man while preserving the natural environment. Since I feel that management of water resources starts with impounding water, you may hear me talk about dams quite often in the next few minutes. Of course, I admit a liking towards those beautiful and useful structures.

In some parts of the world, we face problems of water pollution – yet there is much water that is not used or is used unwisely. In others, there is a lack of water. In yet others, there are floods and large surpluses. Solving these problems is all a part of water management. And some of the points I shall touch on might apply, I believe, to other kinds of environmental problems. As a general statement it seems to me that, if we managed our water resources properly, we would solve most other environmental problems.

Certainly, during this exposé, I hope to raise some questions in your minds. Are we identifying the real problems? Are we certain of the causes? Or are the problems we are attacking spurious, superficial, or downright fallacious? Might some, in whole or in part, be insoluble?

Let's start with a few premises. First, in our evolving world there are no solutions for all time. We must face the fact that it is impossible to imagine, let alone chart, all the unknown repercussions of changes in the natural scheme of things. This does not mean, of course, that we can take a laissez-faire attitude and do nothing. We must take measures to alleviate or prevent any serious negative repercussions that we can foresee or that arise from whatever cause. We must monitor results and with improved technology correct problems as they arise. We must try to solve problems. It is irresponsible to be always *against*, we must be *for* solutions, even if they are not for all time.

My second premise is that solutions to environmental problems are always a trade-off. Today, all of us, including those who must decide on such solutions, are more aware than people have been in the past of the possible detrimental effects of our actions on ecologies, human and otherwise. Those who make the decisions try to choose solutions in which benefits outweigh detriments. But there is no solution to such problems that will give us 100 per cent benefit and zero detriment.

My third premise is that nature itself is not always the best teacher. And if one fact about nature stands out loud and clear, it is that it does not infallibly solve its own problems with benefit for all and harm for none. Globally, as well as individually, nature is red in tooth and claw. In fact, over geological time, it does not seem to have done much better than mankind has in its comparatively short span. Whole species, families, and orders of creatures and plants have evolved, flourished, and vanished.

Have you seen a glyptodon lately? Or, for that matter, a sabre-toothed tiger or a giant beaver? As a recent article in *Science News* put it: "Just when it was looking really bad for the dinosaurs, it got worse. Another element has been added to the already dire scene painted of the world 65 million years ago. Some scientists [suggest] that is when an asteroid or torrent of comets pelted the planet, wiping out the dinosaurs and hordes of other life. In addition to the possible dust clouds, blast waves, tidal waves and poisonous gases triggered by the impact, researchers at the University of Chicago have added yet another deadly plague: continent-size wildfires churning out massive clouds of soot that engulfed the globe."

"Their findings not only increased understanding of the forces that drove the dinosaurs to extinction, but they provide a much needed quantitative basis of studies of future cataclysms that could befall the earth."

You may argue that the catastrophes that wiped out the dinosaurs were great for our mammalian ancestors and for ourselves. The dinosaurs probably looked at it differently.

Just recently we have seen natural calamity take a heavy toll of life in Colombia. It has been called a second Herculaneum. I have not heard anyone blaming nature for killing 20,000 people. I *have* heard charges that the government was told this might happen and should have done something to prevent it!

My fourth premise is that there are social problems that are very difficult, if not impossible, to solve. Since we have some of our own, I need not elaborate, except to point out that some of these problems, though different, are more knotty and more acute in developing countries. For instance, some developing countries are locked into a vicious circle, as improvements in health care and the standard of living have favoured population explosion. Then there are differences in religious beliefs or bad feelings coming from historical events that sometimes go far back in time and make people doubtful about sharing natural resources, which are plentiful in some countries but not in others (or even inside the same country). There are ways of life in many developing countries that have existed for centuries and are hard to change.

Therefore, we cannot simply apply strict environmental rules. We must strike a balance. In my opinion the control, harnessing, storage, and management of water resources is the last hope for many of these developing countries.

With our plentiful resources of fresh water in Canada, we are apt to be glib about it. But in parts of the world where water is lacking, the biblical phrase, "the water of life," rings as true today as it did in the days of the nomad patriarchs. Above all, that is so in North Africa and in the Sahel countries, which for some time now have watched the Sahara creep outwards year after year. Meteorologists and climatologists are not yet able to determine whether the current drought is a cyclical or a permanent trend. Meanwhile, the desert encroaches across the whole belt south of the Sahara and threatens to gain a stronger grip on the countries surrounding it.

Can modern technology help to solve this problem? I believe so. The approach that springs most readily to mind is to build large man-made lakes to store water, replenish aquifers, irrigate the land, control floods, and regulate flows for navigation.

It is therefore ironic that, when the need is so great, large dams are coming under increasingly heavy fire from environmental groups. For the first time in history, we saw demonstrators at the Congress of the International Commission on Large Dams, held in Lausanne earlier this year. These groups charge that large dams cause widespread damage to the environment. They have even gone so far as to urge international lending agencies to stop funding Third World water projects. Or, if there are to be water projects in the Third World, they argue that any dams built should be small.

Let us take a cool, scientific look at dams and the reservoirs they create. Any reservoir, even one you make at your country place for a swimming pool or trout pond, will have certain effects on the environment. Some of these effects can always be construed as negative, depending on your point of view. The one at your country place may flood land you might have planned to garden. It may diminish the downstream flow. In the shallower parts, it may make a good breeding ground for mosquitos.

But, on the other hand, you have a place for your family and friends to swim. You may have fresh trout on your table if the pond created is large enough. You may have improved the scenery. It is a question of choice that is not 100 per cent on the plus side with no downside. And I am speaking of a very small reservoir.

Evidently, the effects of large reservoirs are more dramatic and more far-reaching. But the fact is that the benefits of large reservoirs can far outweigh the negative, or allegedly negative, effects.

Quite apart from these inevitable effects on the environment, large dams and reservoirs are often blamed for conditions that arise from other causes, principally climate and geography. If we build large man-made lakes, it is usually to counteract, or at least mitigate, these conditions. Or to produce power. Or, sometimes, for other reasons or a combination of reasons.

Let us, just as an example, look at the Sahel countries: Senegal, Mauritania, Mali, Burkina Faso, Niger, Chad, Sudan, and Ethiopia. We might regard these countries as a vast laboratory. This is a part of Africa that used to be green. Now, particularly in the north, it is rapidly turning to desert. The populations suffer from hunger . . . and thirst. What are the causes?

Although there has been less rainfall than usual in recent years, these countries usually have an annual rainfall of 700 to 800 millimetres – the same as continental Europe. The difference is the distribution of rainfall over a year: in the Sahel, most falls in the rainy season. But, because of the types of soil and the underlying rock, which is worn-down Precambrian granite, with few depressions or irregularities, most of it runs away. Lakes are rare. By contrast, central Tunisia, just to the north, has much less rainfall – an average of 300 millimetres a year – but floods occur there, and the soil and underlying rock retain the water.

The basic problems I have mentioned so far are caused by climate and geography. Now we come to some that are man-made and, curiously enough, some spring from excellent intentions.

Since decolonization, foreign aid has increased and is still increasing in these countries. One result is that infant mortality has diminished. Life expectancy among the whole population has doubled in the last 10 years. So the population throughout the Sahel is growing. Meanwhile, food production, at least for domestic use, has not increased. On the contrary, it has diminished because of overgrazing. This practice and its effects on vegetation are not limited to the Sahel. Texas and New Mexico have faced similar ecological problems where cattle ranching has upset the balance of nature. To compound matters, cattle are used as currency in the Sahel, which has led to the overgrowth of herds. Fruit and vegetable cultivation has tended to give way to herding. Once the natural vegetation is destroyed, it takes a long, long time to restore it.

The traditional crops in these countries were diversified. Since independence, many African countries have tried to build up their exports and balance-of-payments by industrialized cultivation of such crops as peanuts or coffee. For large plantations, trees had to be cut, and the disappearance of the trees has contributed to higher aridity and growth of the desert. Then, in mid-development, the Sahel countries, like all of us, were hit by the world economic crisis. Now they cannot produce enough to feed their own people, nor can they keep their balance-of-payments in line.

Some have tried to solve the water problem, for this seems to promise the only way to break out of the vicious circle in which these countries are caught. Let us, therefore, examine some large man-made lake projects – past, present, and planned – and look at their influence on the proper management of water resources for the most good to many and least harm to few.

Nasser Lake was created by the Aswan Dam, on the upper Nile on the border of Egypt and Sudan, and went into operation some 20 years ago. It was originally built for electricity production; this, however, did not prevent use of the reservoir for irrigation. Other advantages of Nasser Lake are that there are few heavy floods on the Nile now, the flow is fairly constant, and the river is open to navigation whereas, in the past, it was possible only at certain seasons.

Aswan Dam has nevertheless been criticized. It has, it is true, upset millennia-old patterns of cultivation in the lower Nile Valley, where the fellahin depended on the flooding Nile, laden with rich silt, to fertilize their fields. They have had to alter their methods, but nowadays they can, and do, use commercial fertilizers. It has also depleted sardine fisheries in the delta because, deprived of the detritus they fed on, brought down by the flooding Nile, the sardines have gone elsewhere.

But in the recent years of lower rainfall in the region, though the Nasser reservoir level has gone down, we have not heard of famine in Egypt or northern Sudan. I would say, offhand, that the water situation in Egypt and northern Sudan is better than it has been for centuries, or ever. The reservoir is in the process of filling again. This goes to prove that we must try to make wise choices, knowing that none will offer us 100 per cent benefits and zero disadvantages.

Akusombu Dam, in Ghana (not a Sahel country) is another interesting case. The dam, originally built for electricity production, created a huge reservoir which was later used to develop fisheries. Today, the fisheries are as profitable as the electricity.

The man-made lake created by the Bourguiba Dam, an SNC project in Tunisia, was built primarily to control the fierce flash floods that in past heavy rainy seasons have from time to time devastated the Kairouan Plain. The dam is on a wadi that is almost dry most of the year, and the reservoir is gradually filling. Meanwhile the Tunisians are building irrigation works, and the regulation of the flow is replenishing water tables downstream and alleviating the aridity that hampers crop growth in most seasons. Freed from the threat of floods, more farmers are moving into the region and planting crops.

A huge international project is now underway to control the flow of the Senegal River, primarily for agricultural use. The three countries that will benefit – Mauritania, Mali, and Senegal – have joined forces to seek foreign aid for the project. Aid is coming, in the form of funds and modern technology, from all over the world. Thousands upon thousands of hectares will be irrigated. So far, two reservoirs for storage and flow control are being created by the Manantali and Diama Dams. The control of the flow will also improve navigation, thus providing a fast and fairly inexpensive way for growers to ship their crops to markets.

In Burkina Faso, with funding from CIDA and seven other aid agencies in various parts of the world, a multipurpose reservoir will be created by a dam now under construction on the Kompienga River. The reservoir will be used to produce power, develop inland fisheries, and store water for irrigation.

This is an SNC project, and we have a letter from the World Health Organization congratulating us on the scheme, which WHO is confident will destroy the breeding grounds of a fly that carries a particularly nasty parasite that causes blindness. About one-third of the people in the region are blind. The reservoir will, however, WHO reckons, provide breeding grounds for mosquitos, and hence raise the incidence of malaria and bilharzia. But these two diseases, unlike blindness, can be cured and controlled fairly easily. In fact, a medicine in the simple form of a pill will clear up bilharzia in a few days. Environmental groups who criticize African dam projects seem to be unaware of this. Kompienga reservoir is an excellent example of choosing the lesser of various evils.

I have spoken of some man-made lakes built in the past and some being built now, and of what I consider their positive influence on better water management. Should we build others? Are our technology and our knowledge sufficient that we can confidently go ahead and build large dams to stop the march of the deserts? I believe they are, and I believe reservoirs are the main part of the solution to the growing aridity and famine, above all in the Sahel.

Not only is there an acute and growing problem of aridity, but there is a growing need for low-cost power from renewable resources. Hydroelectric dams appear to be, in my view, the best answer technology offers at the moment.

Should these dams be small or large? Village hydro projects have been tried. They are better than none, and some have proved useful in dry spells if evaporation did not reduce their usefulness too fast. But it takes just as much technological know-how to build a small dam as a large one, mainly because of the problem of building a spillway to handle the high run-off. And the problem of flood and flow control, which lies at the heart of bringing water to those in need, is the same with a small dam as with a large one.

If we can find a way to do it efficiently in a small project, then it will cost so much that we might as well, if topography permits, go ahead and build a large dam. I would, however, like to repeat what I said at the Lausanne Congress earlier this year: "If studies indicate a large dam should be built, that is what should be built. If they indicate a small dam should be built, then a small dam should be built. And if they indicate no dam should be built, then no dam should be built."

On the other hand, Africa does have large rivers. If we can regularise the flow so that it is more or less constant in dry seasons and in wet, we shall be able to irrigate enormous tracts of land. Should we regulate the mighty Niger with three or four reservoirs? By doing so, we could turn large parts of the African Sahel into a vast garden rather like California, which has reached its present point of high agricultural production through the total use of the waters of the Colorado, and other water resources.

A man-made lake on the Niger has already been proposed – a $750 million project on the Niger-Mali border. But the project has been postponed while the two countries negotiate. Besides, the cost is almost as high as the annual budget of either country. The cost of financing, therefore, is just too high. This is a stumbling block encountered again and again in the Sahel countries.

One solution is to follow the example set on the Senegal project. Several countries might band together and gain the support of international agencies in the developed world who could guarantee the loans. One should bear in mind also that the possible multipurpose uses of large reservoirs would go some way towards paying for the project over a period of years.

The building of reservoirs is the first step only. International agencies like the UNDP and FAO have an important job to do, as do aid agencies in various countries. For large water storage and irrigation projects to succeed, the population that will potentially benefit must change its agricultural methods. Will the people of Sahel be willing to do so? In much more advanced countries, traditional farmers have often been reluctant to change. On the other hand, such programs have been outstandingly successful in India. Perhaps it would help if we, in the developed world, gave them more practical help. For instance, we might send out farmers as well as agronomists.

In the Third World, in the Sahel above all, humanity cannot afford to ignore the benefits of large man-made lakes created by dams. Negative effects, like the flooding of settled or potentially productive countryside, must be balanced against the even more negative ones of widespread famine, death, and the turning to desert of once green and fruitful land. In the case of electric power, a cheap renewable source of power must be balanced against economic stagnation in countries that need to build up agriculture and industry to become self-sufficient, let alone export.

It is not only in the Sahel and other parts of the world that water is unequally distributed. We have the same problem right here on this continent, in this country. And here, eventually, the preservation of the environment of large tracts of North America will demand a policy of sharing our water resources, nationally and internationally. The time is coming, and it is not far off, when each region will no longer be able to afford to have its own local or regional reservoir and canal systems.

The protection of the environment is not only a question of safeguarding some rare kinds of fish or fowl. We all know that thousands of species have evolved and disappeared over the millennia without man having anything to do with it. We are fortunate in that, today, our technology and our understanding of ecological patterns and processes make it possible for us to forestall some of the changes that are, after all, inherent in nature.

I feel that we can create man-made lakes to store water, irrigate the land and produce power, *and* at the same time preserve and improve the natural environment. But to do so we must adopt as our motto: "It is not *who* is right, but *what* is right." The protection of the environment comes down, in the end, to the preservation and amelioration of the land we live on and of the lot of the people who live on it – at least as much as of the lot of the flora and fauna. We must do our best to insure that we all win by improving the general situation of things.

Once land deteriorates, erodes, or becomes desert, it is costly and, sometimes, nearly impossible to restore. For one thing, the deterioration of land affects the whole of nature, rebounding on the climate, on flora, and on fauna.

It is not so costly or difficult to manage our resources and to keep land in good condition. We can do it, but perhaps we lack the political will. Perhaps the public and the press, which can shape that political will, are indifferent or uninformed; perhaps they listen too readily to some of the shriller and half-informed environmental groups who are all too ready to criticize the engineers, technologists, and others who are trying to solve problems created by such things as geography, climate, and centuries of misuse.

Here in Canada, the Grand Canal project has been much in the news lately. This is a suggestion for better use, management, and more equitable sharing of our continental water resources. Yet, already, before studies have been made, the concept is coming under heavy fire, not entirely for its environmental effects – which must yet be explored fully – but no doubt because of the size of the undertaking and fear of change. This possibility recognizes the long-term problem of water demand in North America and the need to make the ultimate use of fresh water before losing it to salt water. The project may be ahead of its time but maybe not that much. The exporting of electricity to the United States is now an accepted fact. So will the export of water.

I, or any engineer, would readily concede that it would be foolish to go ahead with a project of such a vast scale without exploring all the negative environmental effects *and* benefits. Only when one has all the facts can one make a wise choice. As in any other far-reaching decision, decisions on large water projects should be based on the principle of the greatest good to the greatest number, and the least harm to any number. That is the choice that faces us today, in arid lands at home and abroad.

What, then, are the policies we should follow? We must set, as priority number one, the proper management of all water resources. Second, water resources must be shared with neighbouring countries that face shortages. Third, we must teach new methods of cultivation and stockraising. Fourth, and most important for the Third World, we must find innovative ways of financing water projects vital to human, animal, and plant survival, and to progress. Fifth, we should always take the man-made and natural environments into account in planning and designing water projects. And, last, the thing we cannot afford to do is to give up building dams aimed at creating man-made lakes that will improve the management of our water resources and the protection of the human species and the environment.

7 Air Quality and the Energy-Environment Interface

Presentation by F. Kenneth Hare

The term "air quality" belongs in the vocabulary of economists and engineers rather than of atmospheric scientists, of whom I am one. We talk about air pollution, or simply about the composition of air, pure and impure. This is not an idle distinction. The word quality implies value, specifically value to human beings. At the outset I must make it clear that my own approach is via the atmospheric sciences. This doesn't mean that I don't value clean air. But it *does* mean that I am not skilled in the issues of cost and benefit that arise from the maintenance of air quality. That will become obvious as I proceed.

Air is, of course, a complex mixture even in its pure state. The dominant gases, nitrogen and oxygen, make up over 99 per cent of its dry mass. Yet most problems of quality concern other constituents. The water vapour, minor gases, and particle load play key roles in the processes of weather and climate. It is precisely these less abundant constituents that are most affected by human interference.

The quality of air for human purposes therefore depends highly on the use we make of it. Industrial residuals (another word from the economist's vocabulary) are largely responsible for what we see as variations in air quality. By far the greater part of these residuals comes from energy generation and use. The major human releases to the atmosphere are carbon dioxide gas, produced in combustion (of which sulphur dioxide and the oxides of "odd" nitrogen, NO_X, are the major constituents).

The professionals who have traditionally dealt with air quality are engineers, public health officials, and, most recently, environmental economists. The central object of their work has been the protection of public health, amenity, and the local environment. The emphasis has been upon those emissions which are toxic, noxious, or just unwelcome to human subjects. I have a long shelf full of works in the field, some by engineers who specialize in air pollution control, some by public health specialists, but most by economists. I have been distantly associated with the environmental group at Resources for the Future (RFF), for long Allen Kneese's base, and owe a good deal to its innovative work.[1]

Within the past decade and a half, however, attention has shifted towards large-scale problems created by regional or global dispersal of pollutants. Whereas the past literature concentrated on the aureole of impact close to identifiable sources, today it is often concerned with the effect of pollution on subcontinental areas or even on the entire planet. Acid rain and the greenhouse effect are examples. Others include the so-called ozone problem (the fear that persistent pollutants like the halocarbons may dissociate stratospheric ozone and hence weaken the screen against ultraviolet radiation), and the nuclear winter hypothesis, the potential post-attack cooling of climate that might be caused by large volumes of sooty smoke.[2]

My own interests lie with these large-scale issues. The atmosphere is remarkably good at stirring itself. Insoluble gases released in this hemisphere infallibly show up in Antarctica within less than a year. Some of these gases, like carbon dioxide, may alter world climate and hence create immense economic challenges and opportunities. Others, like the oxides of sulphur and nitrogen, are more soluble and get washed out. But even so, they may acidify precipitation up to hundreds of kilometres from the sources, which themselves tend to be dispersed or mobile.

In this framework the idea of air quality seems a little inadequate, as does the concept of "airshed," though they are both defensible in local analyses. Water converges gravitationally and forms streams that are truly the collectors of surplus water over a watershed. Air does the reverse: it disperses, diffuses, and moves divergently anything added to it. Hence the tendency for distant impacts. It is with these dispersed consequences that I shall deal today.

The Greenhouse Effect

The most unmistakably global impact is that due to the release of carbon dioxide, chiefly from fossil fuel consumption – coal, oil, and natural gas – now running at 5 gigatonnes of carbon per annum ($Gt\ C\ a^{-1}$). Carbon dioxide, CO_2, is an abundant natural constituent of air. In pre-industrial days it made up about 270 parts per million by volume (ppmv) of the atmosphere, or 0.027 per cent. Concentrations are now near 345 ppmv, meaning that about 75 ppmv have been added to the mass of carbon in the atmosphere since the industrial revolution. Since detailed monitoring began in 1957 (at Mauna Loa, in Hawaii), concentrations have risen by 30 ppmv, a rise of 9.5 per cent in 28 years.[3]

Obviously, that is global change on the grand scale. But the vocabularies of air quality or air pollution lack the words to accommodate it. There are no simple sources or targets. CO_2 is released wherever human beings work, quite apart from the fact that it is produced universally by the natural biological process of respiration – basically the decay of organic material. It is a poorly soluble gas, and so it is not quickly scavenged by rain. The winds carry it worldwide. Hence the consequences of the CO_2 build-up are even more universal than its sources. And finally, my friends in the air pollution business stumble over calling it a pollutant, because it is a harmless, even beneficial, natural constituent of air.

The carbon cycle operates on a giant scale. Of the 5 Gt of carbon released annually by human activities, about 3 Gt remain in the atmosphere. The rest presumably enters the ocean, though its fate is controversial. But these transfers are small by comparison with the scale on which the biota works. Something like 500 Gt of carbon are bound up in standing vegetation on land, and this exchanges something like 50 Gt of carbon per annum with the atmospheric store of 725 Gt. Hence the release of carbon by our economy is still only one-tenth the annual interchange between field, forest, and atmosphere. Nevertheless, human action has effectively unbalanced the system – the system that comprehends all life, including ourselves.

Since photosynthesis in most green plants is actually fertilized by CO_2 enrichment and since human beings do well at much higher concentrations than those observed, it might be thought that the CO_2 build-up would be a positive influence, leading *inter alia* to higher crop yields. But this fertilization effect, though real enough, is only one of many consequences. Much more important is the climatic change that must follow from the fact that the CO_2 build-up increases the opacity of the atmosphere to the sort of infrared radiation emitted by the earth's surface. Solar radiation is largely unaffected by the build-up. Solar energy reaches the earth's surface unimpeded; but the return flow of infrared radiation to space takes place under conditions of higher resistance. Hence temperature must rise at the surface and fall a little in the stratosphere. For doubled CO_2, the mean annual surface air temperature is expected to rise by about 2° celsius in the tropics, and by 3 to 7° C in Canada. This is the so-called greenhouse effect.[4]

CO_2 is not alone in creating this potential warming. Other pollutants, or altered natural emissions, work the same way. Among the latter, releases of methane (CH_4) and nitrous oxide (N_2O) have been increasing. Among synthetic pollutants with similar optical properties, the chlorofluoromethanes (CFMs, usually known by the DuPont trade name, Freons) are also known to be effective in raising temperatures. It is now reckoned by most authorities that all these infrared absorbers together may add at least 50 per cent to, and perhaps double, the CO_2 greenhouse warming. A warmer world is in prospect, unless some gigantic compensating mechanism exists, as yet unidentified.

A warmer world is not one from which most Canadians would recoil. But there will be associated effects on precipitation, evaporation, and streamflow that may not work to this country's advantage. Among the obvious but imperfectly understood effects, the following stand out:

1) it is expected that the surplus of precipitation over evaporation – the source of stored soil water and of run-off – will be diminished in mid-latitude areas. This means that agriculture, navigation, water supply, power generation, pollutant transport, and dilution may all be adversely affected;

2) the rise of air temperatures will increase the length of the growing season, bringing many regions of Canada within reach of more diverse and productive forms of agriculture if water supply is adequate. By the same token, forest increment, forest diseases, and forest fires are also likely to be encouraged. We are talking here of changes in potential growth of the order of one-quarter to one-third;

3) the annual freeze-up in Canada will be shortened. The Great Lakes-St. Lawrence system will be more easily navigated and managed, though there are grounds for supposing that lower water levels will work in the reverse sense.[5] The winter of 1982-83 happens, by chance, to have rehearsed these effects by being about as warm as is expected from a CO_2 doubling. Navigation in the Arctic Archipelago will be dramatically easier. The pack ice of the Arctic Ocean will be less thick and less extensive but will not disappear. Sea levels will continue their slow rise, conceivably by up to a metre in the next century.

There are many other consequences, but I must be brief. The effects on Canada are currently being modeled by research within the Canadian Climate Programme, which is coordinated by a Planning Board representing of federal, provincial, and private interests. I call the Council's attention especially to three major impact analyses now in progress. One is a review of the potential impact on Great Lakes activities, led by Marie Sanderson at the Great Lakes Institute of the University of Windsor. Another is a series of studies of Prairie agriculture led by D. Kraft, of the University of Manitoba, and coordinated with the excellent work of the Prairie Farm Rehabilitation Administration in Regina. Third is work by the Land Resources Group of the University of Guelph on the possible effects on Ontario agriculture. Finally, I have stuck my own neck out as regards the Ontario problem by trying to foresee the province's environmental future.[6]

The Council will note, therefore, that the consequences of the greenhouse effect are being examined closely by myself and my colleagues in many disciplines. Climate impact assessment is a new interdisciplinary activity that is only now beginning to crystallize its methods.[7] Within a brief period I hope that we shall be able to persuade economists (who have so far been rather sceptical of the effort) that climatic variation can be foreshadowed, and its consequences modeled sufficiently for us to include them in our planning for the future. At the very least, we should be able to write credible scenarios of possible future conditions.

These effects may already have shown themselves, in that world temperatures have indeed risen in the past century. I doubt whether the recent drought years in parts of the Prairies are due to the greenhouse effect, but they are grim reminders that the tendency of the CO_2 warming is to increase the frequency of such difficult years in western Canada. In any case, I fully expect the main outlines of the published scenarios to be confirmed by events within the next two decades. If so, our work will have been worthwhile; if not, it can be buried thankfully.

The greenhouse effect arises very largely from the consumption of fossil fuels. If real – and I have little doubt of it – the effect will have enormous strategic and economic consequences that will far outweigh the acid rain question. Because all countries will be affected, a trading nation like Canada must concern itself with the effect on her foreign partners. Let me emphasize a few others. We have, for example, a large exportable surplus of farm and forest products. Though the greenhouse effect will pose problems for domestic producers, it is my personal view that these can be overcome by technological adaptation – for example, by the substitution of winter for spring wheat in the Prairies, or of corn varieties now used in Kansas and Nebraska for those currently sown in southern Ontario. I am very confident that the resourcefulness of Canadian agricultural research and the alertness of her farmers will make such adaptation possible. I am hopeful, though not as confident, that the forest industries can similarly adapt.

In contrast, the agriculture of the Soviet Union is at much greater risk; bureaucratic rigidity is coupled with extremely difficult climates in the Siberian new lands and with increasing water supply problems in the Ukraine, the Volga-Caspian Sea. basin, and the irrigated areas of the southeast. Shortfalls of USSR grain production have been an opportunity for the Canadian Wheat Board and the farmers behind it. And the great granary of the U.S. Midwest and Great Plains is also threatened. It is conceivable that the changes might work to Canada's commercial advantage. Beyond this parochial view, however, one can discern enormous strategic issues. Anything that disturbs the world food system contains threats to stability. We are only beginning to speculate about what those threats might be.

When will these stressful changes occur? As I have said, they are already detectable in some people's eyes and should be beyond argument before the end of the century, if fossil fuel burning expands as expected. By 2025 they will be big news. This is still beyond the timescale of political action, but it is already time to incorporate provisions for the threatened changes into long-term capital investment decisions and strategic questions in general. And it is urgent *now* that we press forward research into climatic change – the main thrust of the World Climate Programme – and into the sensitivity of the economic sectors to climatic stresses. We are still a long way from the necessary capacity for detailed prediction in either domain.

The Council will note that these questions are all world-scale. The carbon dioxide issue is fundamentally global. Local and regional institutions can consider adaptations, commercial advantages, and regional imbalances. But only world institutions can tackle the major issues of possible control and strategic defense. So far the study of these questions has been left to the U.N. agencies, notably the World Meteorological Organization, and to the International Council of Scientific Unions through its Scientific Committee on Problems of the Environment (SCOPE). There is a need for bodies like the World Bank, the International Monetary Fund, the Canadian International Development Agency, and the International Development Research Centre to keep a well-informed and wary eye on the long-term strategies of especially the developing world, where there is a potential for both gains and losses – and for stark tragedy, as Ethiopia has shown.

And I include the Economic Council of Canada. For some time I have felt that the Council should take a closer look at long-term environmental pressures, not only in terms of hazards, but primarily in terms of potential opportunities. Among these, the potential effects of climatic change rank high. Canada's economic welfare depends heavily, not only on the performance of her own climate, but on those of her customers and competitors.

Acid Deposition

By comparison with the greenhouse effect, acid deposition is a regional problem. It has so far been regionally damaging, rather than a factor in world environmental change. The areas most affected are eastern and northeastern North America, and northern, northwestern, and northeastern Europe. Local air pollution occurs worldwide. But the pollutants that attack, for example, the Parthenon or the old limestone façaces in Christchurch, New Zealand, are local, and they are chiefly deposited dry. They can be locally controlled. This is not true of the major areas of deposition, where some hundreds of kilometres may separate culprit sources from victim receptors.

Acid deposition is thus a multilateral problem in Europe, where many small but heavily industrialized countries are emitters, and many small countries are receptors. The problems now confronting the Federal Republic of Germany, Denmark, Sweden, Norway, the German Democratic Republic, Poland, the Soviet Union, Austria, Italy, Hungary, Switzerland, and even France, and the United Kingdom (though the latter are reluctant to admit that they either emit or receive) are all serious, and are all inextricably linked. In North America the problem, by contrast, is on the face of it bilateral; the United States and Canada exchange pollutants freely along their indefensible border. But several provinces and many states are involved, so multilateral complexity is not far away.

Heavily industrialized areas burn much fossil fuel, some of it sulphur-rich coal, which yields sulphur dioxide, the precursor gas of sulphate particles. They also use immense quantities of gasoline (much of it still leaded), diesel fuel, and heavy fuel oils. There are consequent releases of hydrocarbons (gaseous and particulate), soot, chemically active oxides of nitrogen and sulphur, and many synthetic pollutants, such as the halocarbons and stable compounds like sulphur hexafluoride, which are carried worldwide by the winds. The result is that the boundary layer of the atmosphere (the bottom kilometre) becomes heavily charged with sour-smelling, dirty-looking, and very alien constituents. Visibility goes down, the sky whitens, the washing-line darkens, and atmospheric quality obviously deteriorates.

When the sun irradiates this brew, a variety of chemical changes ensues. The heat may dissipate the boundary layer, and the pollutants are then carried away to bother others. But the light, and especially its ultraviolet component, induces chemical reactions, particularly when the air is stable and does not readily mix with the air above. The air in the deep valley systems of Europe, Pennsylvania, the Hamilton-Dundas trench in Ontario, and the Vancouver area is often trapped by the surrounding hills. The chemistry then goes on unimpeded by dilution. A mixture of nitrogen oxides, hydrocarbons, and sunshine produces significant concentrations of oxidants capable of attacking green plant tissues and many solid surfaces. Ozone is the chief offender. At night the oxidants thin out again, but the next morning the process resumes.

The acid rain crises of the 1970s and early 1980s arose from the recognition, first in Europe and then in North America, that sulphates and nitrates from the above-mentioned pollutant mixture could acidify cloud droplets, and hence falling rain and snow. It was the Swedes who first gave prominence to the issue, at the 1972 U.N. Conference on the Human Environment. It had become obvious – and is still the case – that Swedish lakes and rivers in granitic areas were becoming more acidic and that the source was persistent acidity in rain falling from southwesterly winds. Norway followed suit in recognizing the problem. Trajectory analysis suggested that the chief acidifying agent was sulphur dioxide emitted by the chimneys of west European countries, most notably the United Kingdom (which, however, repeatedly denied responsibility). Very quickly Europe convinced itself that this was a continent-wide problem for all areas whose soils could not "buffer" the falling weak acids. The OECD, and later the EEC, put the matter on their agendas, and a massive research enterprise was begun that still continues, as does the attendant monitoring.

In North America, conditions seemed ripe for a similar solution. In the wake of Stockholm, Environment Canada took the initiative that led eventually to the so-called Long-Range Transport of Airborne Pollutants program (LRTAP), a major federal research effort aimed at gauging the reality and impact of acid deposition in Canada. The Government of Ontario also mounted, and continues, a large effort of very high quality. Quebec has also done some good work. In 1983 the federal budget for these purposes exceeded $20 million, though interdepartmental differences robbed this of some of its effectiveness. There has since been a weakening of effort, but much is still being achieved.[8]

In a nutshell, what has been revealed is that a vast area of acidified precipitation does indeed cover North America, southeast of a line from central Texas to James Bay, and thence to the Atlantic coast of Labrador. The acid deposition is at a peak over the Ohio Valley, the southeastern Great Lakes basin, southern Ontario and Quebec, and over New York and New England. Maritime Canada is also affected. Evidence of acidified lakes and streams is abundantly available from areas of alkali-poor soils, chiefly in the Canadian Shield, Adirondacks, and northern New England. Damage to fish populations has been demonstrated in certain lakes, and inferred in many others.

Why, if the facts are reasonably clear, has it been so difficult to persuade the United States to join Canada in remedial action? Some of the facts make the answer clear: it is obvious that the greater part of the sulphur dioxide and nitrogen oxide emissions – the acidifiers – comes from U.S. sources, whereas the bulk of the *damaging* deposition occurs in Canada. The cost of any remedial measures will fall primarily on industries in states that will derive little benefit and whose industrial economies are at a low ebb – notably

Michigan, Illinois, Indiana, Ohio, and Pennsylvania. And, of course, there is the ever-present fact of the doctrinaire conservatism of the Reagan administration, which not very mysteriously prefers the goodwill of Midwestern industry to the long-term conservation of environment and resources. Conservation and conservatism ought to be soul-mates, but they rarely are.

At the core of the U.S. position is the assertion that not enough is known about the problem to identify the culprit areas or point sources, or the processes that carry the acidifiers to their targets. The United Kingdom maintains a similar position in Europe. What are the specifics of the claim?

In the more conciliatory days of the Carter administration, Canada and the United States did indeed sign a "Memorandum of Intent on Transboundary Air Pollution" (MOI) in August 1980, under the stimulus of the draft Geneva Convention of 1979 negotiated by the U.N. Economic Commission for Europe (ECE). The latter body had taken this initiative because, quite obviously, eastern Europe had to be brought into a problem previously studied mainly by the OECD and the EEC. Canada and the United States are members of the ECE, so that the new convention offered a way of proceeding to tackle their own bilateral problem.

Under the MOI, three work groups of officials – federal, state, and provincial – worked for two to three years attempting to specify the problem and recommend solutions. One group analyzed impact; another studied emissions and potential control measures; and a third examined the atmospheric transport and chemistry whereby the pollutants reach the target areas. The work groups achieved scientific and technical consensus on most issues.[9] In certain critical areas, however, differences developed between the two national groups in the later stages of the work.

One was over impact, where Canada took the position that a specific upper limiting value – actually 20 kilogrammes per hectare per annum – of wet sulphate deposition should be the objective of control measures, and that this could be achieved by a 50 per cent reduction of sulphur dioxide emissions.

Many aspects of this proposal proved unacceptable to U.S. negotiators. The elaborate source-receptor models, for example, failed to convince the U.S. team and were also questioned both by the National Academy of Sciences[10] and by a White House peer review group chaired by W. A. Nierenberg, Director of the Scripps Institute at La Jolla. The chemistry whereby the emitted oxides are converted to weak acids was questioned. So also was the extent to which we can infer the relative importance of dry and wet deposition (that is, gaseous deposition or particle fallout versus rain and snow).

In the outcome, there were abundant grounds on which the Reagan administration could base its strategy of delay: more research was (and is) needed into many aspects of the question. But it was the conviction of my Canadian colleagues (I chaired the Canadian peer review[11] that nevertheless there were still grounds for action and that the remaining uncertainties should not delay effective measures of control.

In fact, this amounts to a general principle – one that has obvious parallels in the economic domain. Action must precede certainty, because the latter is unattainable. The natural environment, like human society, is so complex that we never achieve complete understanding. It will always be possible for those opposed to remedial action to hide behind the need for more research. At some point or other, the political will for action must override the uncertainties. And it will always be what Eric Ashby calls "hunch," and not a consensus of research, that pushes the politicians into action.

Another general principle emerges: that research and monitoring are never done and gone. The political stereotype of research is of a process that aims at a specific objective, which, once attained, removes the need for the research. "The time for research is over," say the activists and politicians, "now we want action." The same is true of monitoring. What they should really say is this: "We don't know enough about the problem, but what we do know justifies action. Meanwhile tell the researchers to keep plugging." Everyone in the room knows that precisely the same is true of all economic and social affairs that need to be regulated.

The acid deposition controversy is taking on a new complexion, one that will in my view probably resolve it. There is uproar in the Federal Republic of Germany, and some of her neighbours, over a sudden mortal sickness that seems to have afflicted her forests. Trees are damaged, dying, or dead over large areas, including much-prized national forests in the Schwarzwald and Harz Mountains. Thanks to work by forest and soil scientists, plus the indefatigable clamour of the Green Party, the protection and restoration of the forests has suddenly become an urgent political priority in West Germany, as it has in Austria, Italy, and Switzerland.

The European consensus is that acid deposition alone is not responsible for the forest sickness. It is rather the integrated impact of the complete pollutant package – oxidants, acids, and toxic metals – that is to blame. Control measures must therefore aim at the package, rather than the acid sources alone. And the relative contribution of distant, foreign sources as distinct from local sources may appear to change.

Here in North America, foresters have been sceptical as to the impact of acid deposition on forests and soils. All the length of the Appalachian Cordillera, including New England and the Maritimes, and also across Ontario and Quebec, the surviving forest is in a dubious state. But the visible damage is due overwhelmingly to fire, poor cutting methods, and insect infestation, notably the spruce budworm, the gypsy moth, and other leaf-attacking insects. There have also been devastating diseases affecting specific trees, notably various chestnut, birch, and elm species. Behind this depressing foreground it has been difficult to detect the added impact of acid deposition.

Nevertheless, the impression is growing that not only forests, but also soils and tree crops, are indeed open to damage by what I have called the pollution package. At the time of the MOI reviews, the evidence was quite fragmentary and conflicting. Since then, there have been mounting signs of damage to leaves and root systems, without unequivocal evidence as to the agent of damage. There is long-standing evidence of damage by oxidants, chiefly ozone, downwind from the major conurbations of the Great Lakes-St. Lawrence belt.[12] Trees exposed on high ridges of the Appalachian and Green Mountains exhibit symptoms of die-back and foliar damage. It would be true to say, however, that we have disturbing indications rather than concrete proof of extensive damage to forests and orchards.

Trees and crops rank higher in the domestic economies of the United States and Canada than do fish or even amenity and recreation. If these indications turn into firm warnings that our eastern forests are threatened, the entire weight of these industries' problems will be put into the scale in the other pan from coal. This will probably tip the balance in favour of remedial action. But so far it has not happened.

A further element in the U.S. strategy has been to argue that Canada's emphasis upon sulphur dioxide is misplaced. Nitrogen oxides, it is argued, are as important as sulphur in producing acidity, and in particular contribute to the spring shock of acidity that comes with snowmelt (when nitrates accumulated in winter snow are released). The nitrates come from nitrogen oxides produced by high temperature combustion, especially in car engines. The United States has taken effective measures, via exhaust emission controls, to eliminate this source, whereas Canada has been lenient to a fault. New regulations under the Motor Vehicle Safety Act will come into force, whereby all new light-duty vehicles sold in Canada from September 1st, 1987 will require catalytic converters that will drastically lower our nitrogen oxide emissions. Until that date, however, we remain unable to defend ourselves against this U.S. criticism.[13]

The acid deposition issue remains, therefore, unresolved. I doubt if it quite deserves the front-rank billing it has received in the past few years. But there is no doubt that it is a formidable problem. It should really be seen in a broader perspective – as a component in a pollution package that may well be undermining the productivity and stability of ecosystems all over eastern Canada. When damage appeared in the German forests, it did so with bewildering speed. Stresses evidently accumulate in imperfectly understood ways. This may well be true of our forest resource. The Canadian Forestry Service is very much alert to the problem, and I am indebted to Peter J. Rennie of that Service for repeated briefings.

I remind the Council that the acid deposition issue arises overwhelmingly from energy production and consumption. Smelting also contributes substantially, especially in Canada. Overall, however, this question is like the carbon dioxide issue. How does one use the fossil fuels without paying large regional or global penalties?

In General

To sum up, such a rambling account calls for humbleness on the part of the author. I have tackled a huge topic on the basis of two case studies. I have always said that the case study is the cop-out of the unprepared. Yet here I am doing it, after a lifetime of work in the field. Glib generalizations come more easily to the lips of the newcomer than to old-timers like myself. In the early days of upper-air physics, it used to be said that kudos was inversely proportional to the amount of information available to the speaker. The same principle applies in the present case.

If I have any general conclusion, it is to reiterate my conviction that the impact of energy use on the environment works most visibly on the local scale, but most profoundly on the planetary scale. The easy problems are those within reach – the ones that we can see, like smoke at Nanticoke (though even there it is largely the invisible components that matter). The tough ones are the regional and planetary items that I have discussed this morning.

Economic analysis of these questions has not really reached a sophisticated level, because of their complexity and because so many of the parameters are actually unmeasurable quantities. One of the major changes due to sulphur dioxide emission, for example, has been a reduction of visibility all through the midwestern and northeastern regions of North America. A white sky has replaced blue, because of sulphate particle scattering. Visibility is rarely reduced enough to affect aviation, but the loss of amenity is considerable. Here in Toronto, humid southwestern winds in summer invariably bring white skies, a drab haze, and a lack of sparkle. A whole generation of young Canadians have grown up to believe that this is the hallmark of summer. Their earliest ancestors saw the blue skies typical of Texas or Oklahoma. How does one quantify such a loss?

For the health impact, a firmer methodology is established.[14] There are also reasonable ways of including local air pollution effects in basin or local studies.[15] The Ontario Ministry of the Environment addressed the much larger question of the economics of acid precipitation, including linear programming models for evaluation of abatement strategies.[16] Work Group 1 of the MOI exercise reviewed the assessment of benefit from transboundary pollution transport controls. One emerges from such analyses with the feeling that the larger-scale issues are not yet articulated sufficiently for the economist's teeth to sink in satisfactorily: the meal is distinctly bland, even though the appetite and teeth are in good shape.

Nevertheless, these issues readily crystallize into political form. The acid deposition issue has been a major item of debate between Canada and the United States (though not between the United States and Canada). It is a matter of hot political argument in Washington. Both parties attempt to use numbers to support their arguments and scare the voters. From this, too, one emerges with the conviction that the acid deposition and carbon dioxide issues cannot be tackled on such a basis. Stephen Leacock is reported to have answered a request for an economic analysis of the St. Lawrence Seaway with the words: "To hell with economics! It's a magnificient conception, and has got to be built." In the same way, the acid deposition issue will be settled when enough Americans and Canadians say (audibly): "To hell with dead fish, white skies, and dying trees! Let's clean up." Then, and only then, will the numbers fall into place. As a citizen I admit that the same appears true of all real issues: politics is action under pressure, not voluntary reform.

In all of this the climatologist urgently needs the help of the economist. We are not skilled in such issues. We are in a position to bring forward sophisticated analyses of climatic variation, and to monitor the atmosphere worldwide. We can perform, with increasing skill, analyses of climatic impact in specific sectors. But we are out of our depth when we try to assess the importance of these issues in economic decision making. How can we make our message more effective?

Comments by Joseph Cannon (abridged)

As you know, in earlier days I was employed at the U.S. Environmental Protection Agency with responsibility for policy operation in that organization. As a representative of the government of the United States I frequently talked about acid rain. Today I am again a private citizen and a Washington lawyer. And in reflecting on environmental questions, after four years experience with EPA, my major concern regarding environment issues is not that of acid rain. What really worries me is the longer-run issue of stratospheric changes, both the greenhouse effect and ozone depletion. There is no question the impending changes in the stratosphere will have tremendous potential consequence for the whole world, transcending concerns about more local problems, many of which, on this continent at least, are being addressed. Therefore, I underline the importance of Dr. Hare's remarks.

I believe that the greenhouse effect has to be fitted into a broader, politically based, planning process – and not just environmental planning. In addition to scientific experts, many more people should be thinking about it. This is not just a Canadian or U.S. problem; rather it is one which has to be addressed internationally.

We must work hard to focus public attention on stratospheric changes. I think it is possible to get the issue onto the public agenda. In the U.S., for instance, at this very moment the Senate Environment and Public Works Committee is holding hearings on the greenhouse effect, and some notable people are appearing before it.

But we must not allow a polarization of positions to occur on this issue. Nothing will be served if those on the industrial side of the argument say simply that this is just a red herring, a problem where we can do nothing; or that it is an issue peculiar to environmentalists, and we know that their hidden agenda is really to halt industry in its tracks, and so on. On the other hand, I think it would be equally wrong for environmentalists to use this as an issue to terrorize the public in order to further their own agenda in other areas.

There has to be some coming-together of not just environmentalists and industry but public policy makers, scientists, economists, and academics in general to do some thinking about it. One study that we did during my tenure at EPA on climate change and on sea level rise came to a conclusion that there may not be much that we can do about stopping the process or changing the nature of the problem. I'm not as convinced now as I was then that that is true, but I do think that we do need to plan thoughtfully about how we might respond to the different environmental effects on whole communities and societies that, in my view, are inevitably coming.

Comments by Konrad von Moltke

It is clearly not my role to argue chemistry or meteorology with Professor Hare. Even where I might have summarized the, by now, long and complex debate about atmospheric changes differently than he, there is no difference of opinion whatsoever about the basic message, so let me limit myself to one general comment and then try to address the question of what the information he has supplied may mean in terms of public policy, and in particular international public policy.

I have watched the scientific debate about "acid rain," ozone layer depletion, and the greenhouse effect – for these are indeed the three central issues – develop slowly over the years from a rough hypothesis dealing with one of the phenomena, quickly contested, into a growing web of hypotheses, some of which are steadily being validated through the slow and complex process of scientific debate. What is most impressive about this entire process is that it appears to me to have a clear direction: the steadily increasing certainty that we are witnessing significant environmental changes due to atmospheric emissions and that these changes are going to increase rather than decrease unless some very dramatic measures are adopted. Professor Hare's statement, low-key and diffident as it is, fits well into this pattern. I have rarely heard an assessment of the evidence from the scientific point of view that is quite as assertive about the existence and significance of impacts and about the likelihood of future impacts – in particular due to global warming. I have rarely heard a scientist come as close to a flat assertion that global warming is occurring and will continue.

What does this growing body of evidence mean in policy terms? Let me first state something that may appear obvious but that is all too often forgotten: atmospheric emissions are nothing special; they are a particular form of waste disposal. For technical reasons, in some instances, they represent the only viable form of waste disposal; in other cases, they occur because of economic choices between different forms of waste disposal. I believe it is imperative to focus on such choices where they exist.

At the present time, waste disposal to the atmosphere is almost always the cheapest form of waste disposal. From an economic point of view, it may be rational to prefer this form of waste disposal to all others. From a social point of view, the disposal of wastes to the atmosphere is clearly the least desirable form of waste disposal, less desirable even than waste disposal to water (otherwise known as emissions to water). Some of the answers to this problem are clearly economic in nature. I will not go into them in detail before this Council, which is more aware of them than I am, but let me say two things.

First, I am personally convinced that it is urgent to attach a fair price to the disposal of wastes to the atmosphere. In my view, the only feasible approach is through an emissions tax, but I am aware that there is scope for argument on this point.

Second, I am equally convinced that the economic instruments this implies will not by themselves solve the allocative problems in relation to atmospheric pollution. The long-standing debate about regulatory measures versus economic incentives is a false debate: these are not alternative means but clearly complementary ones. What little research there has been on joint systems incorporating both regulation and emissions taxes (primarily in the Netherlands and the Federal Republic of Germany) clearly shows that the most effective – and economically satisfactory – strategy is a combination of regulation plus emissions taxes.

This much said, let me address the international issues of atmospheric pollution. First, it must be said that there is no environmental medium that is by nature as international as air. It is nothing short of scandalous that it has taken almost 15 years for international negotiations to reach the point where substantive measures may be required of many states. This is perhaps the most significant failure of international environmental policy to date, and the blame lies squarely on the shoulders of the states involved, with almost no exception. (Norway is probably the country with the best record.)

In Europe, the dam finally broke three years ago when the Federal Republic of Germany discovered extensive and growing damage to trees in its forests, with 1 or 2 per cent of all trees dying off each year. This may not sound like very much, but all one needs to do is to calculate the average life of a tree under these circumstances (between 50 and 60 years) and compare this with the normal periods required for maturity. In effect, this confirmed reports that had been coming in previously but had not yet caused a sustained reaction. With this evidence in West Germany came a change of position on the part of one of the countries that had been most resistant to international air pollution control measures. It was like Saul turned Paul, and the zeal of the German authorities for control measures had all the fervour of the convert.

In Europe, this led to a number of significant measures, both at national and international levels, among which the most important were:

- the adoption, in the Federal Republic of Germany, of a regulation that had been long fought over, establishing new emission standards for major combustion plants, which will require rigorous desulphurisation of both new and existing plants within 10 years;

- agreement in the European Community on a framework Directive ensuring compatible practices in the control of atmospheric emissions in all member states;

- agreement in the EEC on the introduction of unleaded gasoline;
- agreement in the EEC on new standards for automobile emissions, to be phased in over a period of years;
- development of the 30 per cent Club within the Geneva Convention on Long-Range Transboundary Air Pollution, comprising countries willing to make a commitment to reduce total emissions or transboundary transport of SO_2 from their country by at least 30 per cent by 1993. In practice many countries will be reducing their emissions by more than this amount but there remains a risk that some countries may view 30 per cent as the ultimate goal rather than as a way station of policy;
- development of new regulations in the Federal Republic of Germany defining state-of-the-art controls for the prevention of atmospheric emissions, which will result in significantly reduced emissions of a number of dangerous substances from new installations in future, with a political commitment to ensure reductions from existing installations as well; and
- development of a more integrated approach to environmental planning and management in the Netherlands.

There is no time to go into the details of the development of these various steps. It is significant, however, to note what has not been achieved: there has been no international agreement on the most appropriate *distribution* of reductions or of the proper *apportionment of costs* – in other words, on the vital issues of equity between states. As long as this is not the case, the solutions being applied will remain imperfect. Not only is there no agreement on these issues at present, but there are hardly any discussions on them yet. The Commission of the European Communities has proposed a Directive on major combustion plants that should force such a discussion, but, from what one hears, Member states remain unwilling to grasp this particular nettle.

The proper distribution of reductions (or vice versa, the acceptable distribution of emissions) is the environmentally crucial issue: certain levels of emissions can and must be tolerated – but from what sources and in what locations? The German response – to reduce all emissions from all sources – is environmentally sound only in a country like West Germany with excessive demands on environmental resources; it can be economically questionable in many other countries.

The proper attribution of costs is the economically crucial issue. In a general way, the polluter-pays principle applies – but no really satisfactory means of applying it has yet been found. The best available solution still appears to be the equalization of emission costs by some appropriate device.

Again it must be emphasized that while distribution of emissions and distribution of costs are clearly related issues, it is not likely that they will be resolved through a single set of instruments alone.

Thus far, significant action has only occurred on the acid rain agenda. Ozone layer depletion and the greenhouse effect are linked in a variety of ways, even though they are scientifically quite distinct: both are truly global issues requiring truly global solutions, albeit of entirely different dimensions; both are issues based upon complex modeling and a good deal of hypothetical conjecture – i.e., with a relatively weak scientific base; and both are the result of emissions of substances that cannot be disposed of otherwise – i.e., to the extent that they occur, they will be emitted to the atmosphere.

Because action to mitigate ozone depletion is so much easier than action to avoid dramatic global warming, the difficulties encountered in seeking international solutions to ozone depletion are particularly significant. In practice, most West European countries still remain unconvinced of the need for determined action. In March 1985, an international Convention on the ozone layer was signed in Vienna. It is a weak instrument, making the differences of opinion between the signatory states particularly manifest. Its main advantage is that it exists and thus provides a forum for considering the issues of ozone depletion in a continuous manner – and a first forum for beginning to define what kinds of solutions may be envisaged if theories about the greenhouse effect are confirmed.

The only conceivable solution to ozone depletion and the greenhouse effect is the dramatic reduction of emissions of the relevant substances – primarily chlorofluorocarbons, in one instance, and carbon dioxide, in the other. While eliminating CFCs is not impossible and would not have a noticeable overall impact upon our societies, any attempt to achieve even a modest reduction of carbon dioxide emissions (from combustion) would imply very noticeable changes in economic practices. The difficulties encountered in relation to ozone layer depletion are but an indicator of the difficulties to come when it becomes evident that something needs to be done about the "greenhouse effect."

In summary it is fair to say that international efforts to control atmospheric pollution came late but then came fast. We are in the middle of a phase of heightened political activity. As always – and as is proper – the easier solutions have been adopted first, but there is evidence that they will not suffice to deal with the environmental problems at hand. In other words, policy making in this area will become more difficult before it becomes any easier.

Floor Discussion

Question: *Climate change may perhaps be viewed as a challenge for the First (or industrialized) World. But this ignores a First/Third World equity question of enormous magnitude. Might not the kinds of changes needed to reduce the emissions and the building up of carbon dioxide be comparatively easier to achieve than the subsequent massive adaptations to climatic change? The former primarily involves the First (and Second) World, whereas the latter requires response around the world.*

K. Hare: I agree that there is a real threat to world stability inherent in the unknown consequences of climatic change for those least able to defend themselves. The situation was presented as a challenge – of adapting to climatic change – because I do not know how the world can devise an energy future without dumping carbon dioxide into the atmosphere. Many have looked at alternative energy sources. In the West we can think of alternatives, although I am not sure that we should voluntarily adopt them. But, based on my knowledge, I have to assume that the only way for countries such as China, India, and Brazil to develop in economic terms, and thereby become high energy consumption economies, is by the consumption of fossil fuels. If carbon dioxide build-up is inevitable, it is preferable that this be regarded as a challenge, so that we can search for technical solutions to adaptation, look for political institutions that can cope with it, and, above all, seek ways of restoring equity.

Question: *What are the prospects for large-scale weather modification, using new technology?*

K. Hare: The prospects are poor; large-scale technology doesn't exist. Even on a small scale it has been a hit-and-miss business, which as an operational technique has been very disappointing. It is extremely unlikely that we will come up with any usable system of climate control before the greenhouse effect materializes.

8 Environmental Preservation and Economic Growth

Presentation by Allen V. Kneese

In the 1960s, the people of the United States became increasingly aware that the fruits of economic development were infected by the rot of environmental deterioration. Later in that decade and early in the 1970s, concern grew to such an extent that a number of laws were passed by the Congress, aimed not only at stemming the deterioration of the environment, but also at improving its quality. As we move well into the 1980s, environmental concerns, as attested by public opinion polls, are still vividly alive in the United States, but other major national difficulties are upon us. The economy is weak, productivity growth remains low, inflationary pressures still exist, and there appears to be no immediate hope for major improvement. In this adverse economic atmosphere, there is heightened interest in the question of whether the costly environmental regulations that have been put in place are, in fact, worthwhile. To try to shed some light on this question, appeal is often made to an economic evaluation method called benefit-cost analysis.

The Applications of Benefit-Cost Analysis

Benefit-cost analysis was developed initially to evaluate water resources investments by the federal water agencies in the United States, principally the U.S. Bureau of Reclamation and the U.S. Corps of Engineers. The general objective of the method in this application was to provide a useful picture of the costs and gains associated with investments in water development projects. The intellectual "father" of benefit-cost analysis was the nineteenth century Frenchman, Jules Dupuit, who in 1844 wrote an often cited study "On the Measure of the Utility of Public Works." In this remarkable article, he recognized the concept of consumers' surplus and saw that as a result, the benefits of public works usually are not the same thing as the direct revenues that public works projects will generate.

In the United States, the first contributions to development of benefit-cost analysis did not come from the academic or research communities, but rather from government agencies. Water-resources development officials and agencies in our country have, from the very beginning of the nation, been aware of the need for economic evaluation of public works projects. In 1808, Albert Gallatin, President Jefferson's Secretary of the Treasury, produced a report on transportation programs for the new nation, in which he stressed the need for comparing the benefits with the costs of proposed water improvements. Later, the Federal Reclamation Act of 1902, which created the Bureau of Reclamation and was aimed at opening western lands to irrigation, required economic analysis of projects. The Flood Control Act of 1936 proposed a feasibility test for flood control projects that required that the benefits "to whomsoever they accrue" must exceed costs.

In 1946, the Federal Interagency River Basin Committee appointed a subcommittee on benefits and costs to coordinate the practices of federal agencies in making benefit-cost analysis. In 1950, the subcommittee issued a landmark report entitled "Proposed Practices for Economic Analysis of River Basin Projects." This document was fondly known by a generation of water project analysts as the "Green Book." While never fully accepted either by the parent committee or the pertinent federal agencies, this report was remarkably sophisticated in its use of economic analysis and laid an intellectual foundation for research and debate in the water resources area that made it unique among other major reports in the realm of public expenditures. It also provided general guidance for the routine development of benefit-cost analysis of water projects that persists until now, even though a successor report does presently exist that is more adapted to the conditions of the present day.

Following the "Green Book" came some outstanding publications from the research and academic communities. Several volumes that appeared over the past two and a half decades have gone much further than ever before in clarifying the basic ideas underlying benefit-cost analysis and the methods for quantifying them. Otto Eckstein's *Water Resource Development: The Economics of Project Evaluation* (Harvard University Press), which appeared in 1958, is particularly outstanding for its careful review and critique of federal agency practice with respect to benefit-cost analysis. A clear exposition of principles, together with applications to several important cases, was prepared by Jack Hirshleifer, James DeHaven, and Jerome W. Milliman in *Water Supply: Economics Technology and Policy* (University of Chicago Press, 1960). A later study, which was especially notable for its deep probing into applications of systems analysis and computer technology within the framework of benefit-cost analysis, was produced by a group of economists, engineers, and hydrologists at Harvard and published under the title *Design of Water Resource Systems* in 1962 (Harvard University Press). The intervening years have seen considerable additional work on the technique and a gradual expansion of it to areas outside the water resources field, some of them more or less natural extensions of the work on water resources. For example, the last two decades have seen many attempts to evaluate the benefits of outdoor recreation – both water-related and otherwise. A relatively recent book that looks at some applications other than water-related ones but is in the mainline of the traditional benefit-cost analysis, is Ezra Mishan, *Cost-Benefit Analysis* (Praeger Publishers, 1976).

But the most striking development in benefit-cost analysis in recent times has been its application to the economic and environmental consequences of new technologies and scientific and regulatory programs. For example, the Atomic Energy Commission (before the Energy Resources and Development Administration and then the Department of Energy were created) used the technique to evaluate the fast breeder reactor program. A report on this study is found in U.S. Atomic Energy Commission, Division of Reactor Development and Technology, *Updated (1970) Cost-Benefit Analysis of the U.S. Breeder Reactor Program*, Washington 1184 (January 1972). The technique has also been applied to other potential sources of environmental pollution and hazard. Two studies that come to quite contrary conclusions have been made of the Automotive Emissions Control. Volume 4, *The Costs of Benefits of Automotive Emissions Control*, Series No. 19-24 (Washington, D.C.: Government Printing Office, September 1974) was prepared by a committee of the National Academy of Sciences. The other study from a major automotive producer is reported in Clement J. Jackson, *et al.*, "Benefit-Cost Analysis of Automotive Emissions Reductions," Research Laboratory, CMR 2265 (Warren, Mich.: General Motors Corporation, October 15, 1976). Other studies have been or are being conducted in the area of water-quality improvement policies, emissions control from stationary and mobile-air pollution sources, and regulation of toxic substances.

Even while the technique was limited largely to the relatively straightforward problem of evaluating public works, there was much debate among economists about appropriate underlying concepts and methods of making quantitative estimates of benefits and costs – especially of benefits. Some of the discussion surrounded primarily technical issues – e.g., ways of computing consumer surplus and how best to estimate demand functions for various outputs of projects. Others were more clearly value and equity issues – e.g., whether the distribution of benefits and costs among individuals or regions needed to be accounted for or whether it was proper to consider only the sums over all affected parties. Another central issue was what the proper weighting of benefits and costs occurring at different points in time was to be. This is known as the "discounting" issue. The term refers to the question of how to take into account the fact that, normally, the further into the future gains or losses accrue, the less heavily they are weighted by those who stand to do the gaining or losing.

The application of benefit-cost analysis to issues such as nuclear radiation, the storage of atomic waste, and the regulation of toxic substances in the various environmental media (both those substances which are immediately toxic to man and those which affect his life support or value systems) aggravates both the conceptual and quantification problems that existed in water resource applications. There are several reasons for this.

First, while water resource applications often involve the evaluation of public goods in the technical sense that they exhibit jointness in supply, the bulk of outputs from such projects are irrigation water, navigation enhancement, flood control, and municipal and industrial water supplies. These outputs can usually be reasonably evaluated on the basis of some type of market price information, because private developments often produce similar or closely related outputs. In the new application, we are dealing entirely with situations in which useful information from existing markets is difficult, if not impossible, to establish.

Second, such matters as nuclear radiation and toxic materials relate to the exposure of the whole population or large subpopulations to very subtle influences of which they may be entirely unaware. It is difficult to know what normative value individual preferences have under these circumstances, and clever methods for quantifying damages (negative benefits) have to be evolved.

Third, the distributional issues involved in these applications concern not only monetary benefits and costs, but the distribution of actual physical hazard. For example, residents of an industrial city may suffer ill health resulting from pollution associated with the production of goods consumed in another locality. While it is not out of the question that monetary equivalents to these risks could be developed, the ethical value issues involved appear to be deeper than just the associated economic returns. This is especially so if compensation is not actually paid to damaged parties, as in practice it usually is not.

Fourth, we are in some cases dealing with the long-lived effects of a policy decision that could extend to hundreds of thousands of years and many, many human generations. This situation raises the question of how the rights and preferences of future generations can be represented in this decision process. Realistically, the preferences of the existing generation must govern. The question is whether the simple direct desires of existing persons are to count exclusively or whether justice demands that the present generation adopt some ethical rule or rules of a constitutional nature in considering questions of future generations.

Thus the new applications of benefit-cost analysis bristle with ethical, value, and quantification issues. A group of researchers located principally at Resources for the Future and the Universities of Wyoming and New Mexico have, for a number of years, been working on a research program aimed at making progress in the basic understanding and analysis of these issues. In this paper, I want to discuss one of the most substantial thrusts of this research – methods development and the quantitative estimation of benefits from air and water pollution control (air and water quality maintenance or improvement). This program of research received sustained support from the U.S. Environmental Protection Agency.

Clearly, it is not possible, in a relatively brief paper, to fully describe a research program that involved many individuals and spanned issues from evaluating health risks to evaluating reduced visibility. I will proceed, therefore, by discussing one study in some detail and concluding with a commentary on some rather broad methological issues raised by the research conducted so far.

The study I have selected for more detailed explanation is of interest, I think, for two reasons. First, it illustrates one of the methods for coping with the lack of information from markets, noted above – one that has come to be known as "contingent valuation." The CV method asks people about their willingness to pay to obtain a specified environmental improvement or their willingness to accept payment for an environmental degradation. The method seems simple in principle but is in fact very tricky in practice. Second, it is one of the few studies so far conducted that was designed at the outset to yield a benefit estimate for an entire nation. Almost all previous studies have been designed to yield such estimates for a region of some kind – e.g., a metropolitan area, an air or river basin, a national park. The intent of the study was to test a methodology for estimating the economic value of improving and maintaining surface water quality in the United States.

A Survey Research Method for Estimating National Water Quality Benefits[1]

The study involves a national survey that asks respondents directly about their willingness to pay for national programs of pollution control. One may call this the "macro approach," as contrasted with micro approaches that focus on particular regions.

Among other potential advantages of such an approach, two are especially important. First, a randomized national sample of persons can be interviewed that permits well-established statistical procedures to be used to extrapolate the results to the entire population. Second, one can inquire about "intrinsic" or existence benefits as well as user benefits.

The second reason invites a bit of explanation. Because the U.S. population politically supports very expensive programs of water pollution control – much more costly than the benefits to recreational users estimated in another study in the program, for example – the researchers were led to believe that there must be some form or forms of benefits accruing to persons who do not actually use particular water bodies. We termed such benefits variously as intrinsic or existence benefits. These benefits may accrue because persons value the options for possible use that are opened to them when water bodies are cleaned up. This type of value has been discussed widely in the economics literature and has come to be called "option value." Other intrinsic values may accrue from a sense of national pride or rectitude associated with having clean waters. One of the main conclusions of the research reported here is that intrinsic benefits definitely exist with respect to environmental improvements or maintenance. Moreover, and being cautious about the accuracy of the results, not only do they exist, but they are large – perhaps larger than user benefits, in some instances.

Some aspects of the water quality situation make it more appealing for an experimental application of the macro approach than is the case for air quality. Chiefly, the goals of our U.S. policy are set out in a manner that would let most of the population understand what they mean in terms of ordinary experience. The objectives are stated to be to make all the nation's water fishable and swimmable in successive stages. Furthermore, much of the cost of these programs is to be paid from taxes levied at the national levels (taxes financing subsidies to local governments), so that respondents can be realistically asked how much in added tax burden they are willing to pay for improved water quality across the whole nation. Neither of these situations holds with respect to air quality, so it would be much harder to pose understandable and realistic alternatives in a national clean-air survey.

A macro study, then, is potentially useful for doing a benefit-cost analysis for whole national water programs. It should be noted, however, that it is *not* a substitute for site-specific studies in other applications. For example, determining whether or not the benefits of a water quality improvement program in the Potomac estuary outweigh the costs would require a site-specific study.

One problem with national surveys is that they are quite expensive. What made it possible to conduct an experiment with the macro approach, given the available resources, was that the researchers were able to piggyback some water quality questions onto a survey being funded by another source. After the interview for the other survey was completed, the interviewers administered a sequence of benefits questions that had been carefully pretested by researchers on the benefits project. From the respondents' perspective, the two interviews appeared as one long interview. In all, 1,576 personal interviews of a national probability sample of persons 18 years of age and older were completed. The sample was designed, and the interviews were conducted, by Roper and Cantil, a national polling firm.

A penalty of this add-on approach proved to be that an unfortunately large number of persons failed to complete all of the questions. In part, this was because they came at the end of an already fairly lengthy survey and, in part, because it was not possible to undertake special training of the interviewers to administer the benefits section. Because of the likelihood of item response bias (caused by respondents failing to answer individual items), the researchers regarded their estimates as only suggestive and warned against regarding them as definitive. The main intent of the experiment was not to develop definitive estimates at this stage but to test whether a macro approach is applicable to water-quality benefits investigation.

The low response rate presumably could be cured by an improved questionnaire and by training of the interviewers. A study is currently being planned in which both of these elements will exist.

The levels of water quality for which the research team sought willingness to pay estimates are "boatable," "fishable," and "swimmable." These levels were described in words and depicted graphically by means of a "water quality ladder." Use of these categories, two of which are embodied in the law mandating the national water-pollution control program, permitted avoidance of the communications problems associated with describing water quality in terms of the numerous abstract technical measures of pollution (oxygen depletion, for example). Although the boatable-fishable-swimmable categories are widely understood by the public, they did require further specification to ensure that different people perceived them in a similar fashion.

Boatable water was defined in the text of the question as an intermediate level between water that "has oil, raw sewage and other things in it, has no plant or animal life and smells bad" on the one hand, and water that is of fishable quality, on the other. Fishable water covers a fairly large range of water quality. Game fish like bass and trout cannot tolerate water that certain types of fish such as carp and catfish flourish in. In pretests, experiments were made with two levels of fishable water – one for "rough" fish like carp and catfish, and the other for game fish like bass – but a single definition of "fishable" was adopted as water "clean enough so that game fish like bass can live in it" under the assumption that the words "game fish" and "bass" had wide recognition and connoted water of the quality level Congress had in mind. Swimmable water appeared to present less difficulty for popular understanding since the enforcement of water quality for swimming by health authorities has led to widespread awareness that swimming in polluted water can cause illness.

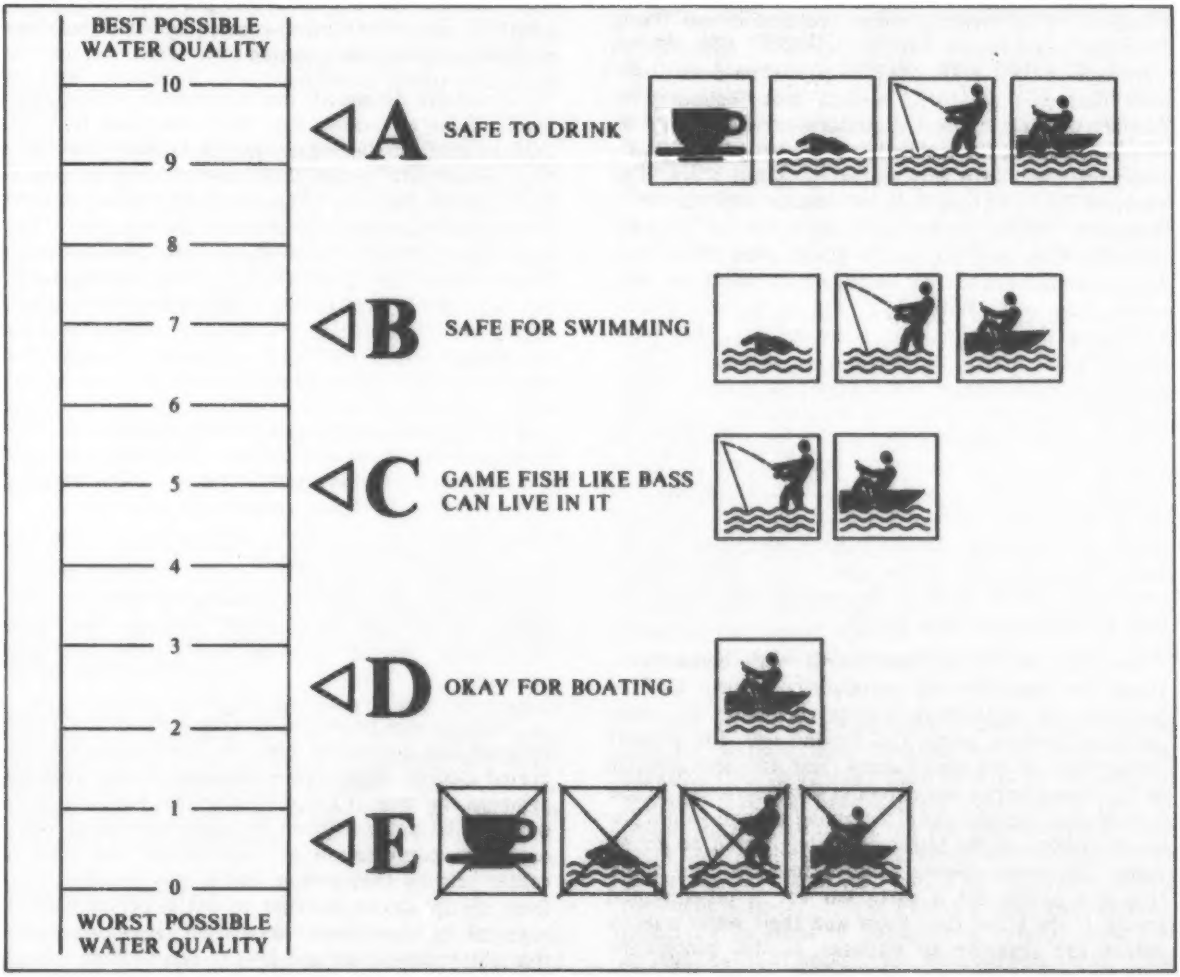
Because willingness-to-pay questions have to describe in some detail the conditions of the "market" for the good, they are inevitably longer than the usual survey-research questions. Respondents quickly become bored and restless if material is read to them without giving them frequent opportunities to express judgments or to look at visual aids. The questionnaire for this experiment was designed to be as interactive as possible by interspersing the text with questions that required the respondents to use the newly described water-quality categories. They were also handed the water-quality ladder card, which was referred to constantly during the sequence of benefits questions.

Figure 8-1 shows the card. The top, step 10, was called the "best possible water quality," and the bottom, step 0, was the "worst possible water quality." The card is "anchored" by designating five levels of water quality at different steps on the ladder. Level E, at .8, was specified as a point on the ladder where the water was even unfit for boating. Level D, 2.5, was where it became okay for boating; C at 5 was fishable; B at 7 was swimmable; and 9.5 was identified as A, where the water is safe to drink.

Questions about willingness to pay should seem realistic to respondents. Accordingly, they were couched in terms of annual household payments in higher prices and taxes, because this is the way people do pay for water-pollution control programs. A portion of each household's annual federal tax payment goes toward the expense of regulating water pollution and

Figure 8-1

Water Quality Ladder Card


BEST POSSIBLE WATER QUALITY
10
9
8
7
6
5
4
3
2
1
0
WORST POSSIBLE WATER QUALITY
A
SAFE TO DRINK
B
SAFE FOR SWIMMING
C
GAME FISH LIKE BASS CAN LIVE IN IT
D
OKAY FOR BOATING
E

providing construction grants for sewage treatment plants. Local sewage taxes pay for the maintenance of these plants. Those private users who incur pollution control expenses, such as manufacturing plants, ultimately pass much or all of the cost along to consumers in higher prices. Thus, this payment method has a true ring for the respondents.

"Starting point bias" can be an important problem in bidding games and surveys. That is, a high starting bid from an interviewer may elicit a higher bid from a respondent than would a low starting bid. This has been a significant problem in many survey-type studies. A major methodological innovation of the research reported in this paper is the development of a device for eliminating such a bias, the "payment card."

In this technique, the respondent is given a card that contains a menu of alternative amounts of payment, beginning at $0 and increasing by a fixed interval until an arbitrarily determined large amount is reached. When the time comes to elicit the willingness-to-pay amount, the respondent is asked to pick a number off the card (or any number in between) that "is the *most* you would be willing to pay in taxes and higher price *each year*" (italics in the questionnaire) for a given level of water quality. Thus, the interviewer suggests no bid at all.

It turns out, however, that this presents some problems of its own. In initial pretests, it was found that the respondents had considerable difficulty in determining their willingness to pay when a card was used that only presented various dollar amounts. A number of them expressed embarrassment, confusion, or resentment at the task, and some who gave amounts indicated they were very uncertain about them. The problem lay with the lack of benchmarks for their estimates. People are not normally aware of the total amounts they pay for public goods even when that amount comes out of their taxes, nor do they know how much they cost. Without a way of psychologically anchoring their estimate in some manner, they were not able to arrive at meaningful estimates. They needed benchmarks of some kind that would convey sufficient information without biasing their responses. The most appropriate benchmarks for willingness to pay for water pollution control would appear to be the amounts they are already paying in higher prices and taxes for other nonenvironmental, publicly provided goods and services. Amounts were identified on the card for several such goods, and further pretests were conducted. These showed the benchmarks made the task meaningful for most people.

But the use of payment cards with benchmarks raises the possibility of introducing its own kind of bias. Are the respondents who gave amounts for water pollution control using the benchmarks for general orientation, or are they basing their amounts directly on the benchmarks themselves in some manner? In the former case, people would be giving unique values for water quality; in the latter case, they would be giving values for water quality relative to what they think they are paying for a particular set of other public goods. If the latter case holds and their water quality values are sensitive to changes in the benchmark amounts or to changes in the set of public goods identified on the payment card, their validity as estimates of consumer surplus for water quality is suspect. A test for this kind of bias was conducted in the pretest by using different versions of the payment card, with the amounts paid for other publicly provided goods being changed by modest amounts. No bias was found, and so the "anchored" payment card was deemed to be a suitable device for the full-scale experiment.

Tests were also conducted in an attempt to discover if any of the other sorts of bias discussed in the literature were inherent in the questionnaire. Again, none were found.

A final point on the payment card. What people actually pay for publicly provided goods varies with their income. To correct for this, four different payment cards were developed, corresponding to four income classes. At the appropriate point in the interview, the interviewer gave the respondent the payment card for his or her income category that had been established by a prior question.

As already discussed, the respondents valued three levels of water quality that were described in words and depicted on the water quality ladder. They were first asked how much they were willing to pay to maintain national water quality in the boatable level. Subsequent questions asked them about their willingness to pay for overall water quality to fishable quality and to swimmable quality. The average willingness-to-pay amounts given by the respondents for the two higher levels consists of the amounts they offered for the lower levels plus any additional amount they offered for the higher level.

The average annual amounts per household (1981 dollars) for those respondents who answered the willingness-to-pay questions turned out to be: boatable, $152; fishable, $194; and swimmable, $225.

The most substantial benefit was for boatable water. The respondents were willing to give about 20 per cent more for fishable water than boatable water, but only about 15 per cent in addition to make the water swimmable. As we will see later, these are large amounts.

The data also permitted making a rough distinction between the recreation and the intrinsic values discussed earlier. Since the willingness-to-pay questions measure the overall value respondents have for water quality, the amount given by each respondent represents the combination of recreational and intrinsic values held by that person. But it was possible to tell from the questions whether or not a person actually engaged in water-based recreation. It was reasoned that the values expressed by the respondents who do *not* engage in in-stream recreation should be almost purely intrinsic in nature. In calculating the average willingness-to-pay amount for the nonrecreators alone, therefore, we get an approximation of the intrinsic value of water quality. By subtracting this amount from the total the recreators are willing to pay, one can estimate, in a rough way, the portion of the recreators' benefits that is attributable to intrinsic values.

When this is done, it is found that intrinsic value constitutes about 45 per cent of the total value for recreators, 100 per cent for the nonrecreators (of course), and about 55 per cent for the sample as a whole. If this is a correct reflection of reality, it is a major finding and may have large implications for the future study of benefits from environmental improvement.

It was noted earlier that, while the sample of persons interviewed was initially chosen at random, quite a few respondents failed to give usable answers. Any aggregate national benefit estimate based on these data could not, therefore, be put forward as accurate. Therefore, I make such an estimate simply to illustrate that the results of this experiment imply very large values.

There are about 80 million households in the United States. Assume that the sample results imply an annual willingness to pay of $200 per household to have high quality recreation waters throughout the country. This would imply a total willingness to pay of $16 billion. According to results explained earlier, this would be divided about equally between user and nonuser values. At first, this might seem quite out of line with the value of well under $1 billion calculated for recreational fishing due to water quality improvement derived by another study in the program, using different methods. But this is not necessarily the case. That estimate is for a relatively small *increase* in the nation's fishable waters over the actual conditions of the early 1970s, and the estimate from the national survey is the value that people attach to making and *maintaining* the whole of the nation's fresh waters of high recreational quality, where the alternative is almost total degradation of most of the nation's watercourses. Thus, most of the calculated benefit is a *preservation* benefit.

The objective of this experiment was not to produce an accurate estimate of national benefits; rather, it was to test the feasibility of using a macro approach to the estimation of water quality benefits. In that, it succeeded, and an improved macro study is now in an advanced stage of planning.

Closing Commentary

In this closing section, I will make some comments based on the entire program of studies mentioned earlier rather than just the one example given here. The interested reader can find a succinct summary of the others in my book *Measuring the Benefits of Clean Air and Water* (Washington, D.C.: Resources for the Future, Inc., 1984). Even more broadly these remarks can be taken to be my perspectives on the whole body of research (at least those portions which I have read) pertaining to the estimation of benefits from environmental preservation or improvement.

It seems fair to claim that the research done over the course of the last decade marks a substantial step forward in our ability to address the issue of benefits from environmental quality improvement or maintenance. Methods have been developed or improved; new data have been collected; some case studies have been provided; and some highly preliminary estimates of national benefits from environmental improvement or maintenance have been presented. Furthermore, some broad insights have, I believe, resulted from the work.

First, while our national air-quality standards are based upon alleged health effects, in fact, it appears that we know very little for sure about the health consequences of air pollution. The team's research work on both aggregate and micro epidemiology is consistent with air pollution as a source of acute effects on an important scale. However, human evidence of chronic effects is tenuous at best. This is certainly not to say there are none, but conclusive demonstration of such effects, or lack thereof, still awaits improved data and methods.

Second, while our air quality standards are, as I said, mostly founded on presumed health impacts, it appears, based on the limited evidence our studies were able to develop, that other economic damages from pollution may be fully as great or even much greater. Damage to materials appears to be a very large cost of poor air quality, but, so far, it has defied accurate quantification. In the preservation-of-values area, it appears that protecting visibility, especially in the West, yields large benefits. In the East, preventing deterioration of watercourse recreational values through acid deposition appears to involve large benefits. But, again, we are, alas, some distance away from a complete and accurate quantification of these values.

Third, the interviewing done in connection with the national water-quality benefits studies, and others, suggests that there may also be a large category of benefits that we have termed "intrinsic." That is, people may be willing to pay for clean areas, in some cases on a really substantial scale, even if they do not benefit directly from their use. This may result from a feeling of national pride in having a clean environment, especially in areas of outstanding natural beauty or unusual cultural importance. Establishing these values in an accurate and complete manner is still a frontier area in benefits research.

Fourth, in the area of water quality a large-scale simulation study suggests that the *additional* benefits to recreational fresh-water fishing from marginal improvements in water quality resulting from implementation of national policy are not impressively large. This is because so much of the nation's water is already fishable. However, the experimental national survey suggests that the willingness of the public to pay to improve and maintain the quality of the nation's water is large – on the order of many billions of dollars per year. That research also suggests that a large portion, perhaps half, of these benefits are of the nonuser, intrinsic variety. This further suggests that, in addition to the value of this type that people may attach to some particularly treasured sites, they may also find a large intrinsic value in achieving certain nationally declared goals such as "swimmable" waters virtually everywhere in the country.

Fifth, methods have been developed to study the agricultural benefits of controlling air pollution. These, in contrast to earlier studies, take account of various economic adaptations and adjustments – for example, crop or variety switching and the elasticity of demand for agricultural products. Early findings suggest that while damages in a highly polluted specialty crop area such as Southern California may be significant, the main source of benefits from reduced pollution could come from major field crops like soybeans and wheat. This is because the total value of production of these crops is so huge that even a relatively small increase in yields is associated with large benefits.

Sixth, a groundwater "episodes" study by members of the team implies that the benefits from protecting large concentrations of population – such as the Atlantic City area, subject of the study – from the toxic pollution of groundwater used for drinking are potentially very large. In most cases, they should easily outweigh the costs of preventive measures.

Finally, I would like to close with some observations of a general methodological character. The methods pursued in the studies can be divided into two broad classes – those based, however indirectly, on observed human behaviour; and those based on asking questions about hypothetical situations. The former are based on actual actions like travel to recreation sites and house prices paid. The attraction of the behaviour-based methods is that they reflect responses to real, not hypothetical, situations and therefore are based on real, not hypothetical, decisions. But these behaviour-based methods have equally real limitations. For one thing, they are not applicable to all situations of interest in environmental benefits evaluation – for example, protecting a beautiful large vista from visual impairment. Further, they are limited to user benefits, and some of the research surveyed here has, as mentioned, suggested that the intrinsic benefits may be very important in certain cases.

For these reasons, resort is made to methods based on asking questions contingent on certain hypothetical situations, as in the water quality study reported on in the previous section. Inevitably, doubts arise about the accuracy of such methods, given the hypothetical nature of the situations they examine.

On the one hand, the research conducted by the team tends to support the view that careful questionnaire design can control previously identified sources of bias (starting point, strategic, etc.); and the South Coast and San Francisco experiments, which were part of the program, tend to support the view that survey-type approaches can provide reasonable indicators of benefits from hypothetical improvements in air quality, at least in certain instances. One reason may be that persons residing in the regions studied especially the Los Angeles area, have a very clear understanding of the situation they find themselves in, have mentally processed much information about it, and have taken decisions based upon it.

Very recent and highly preliminary experiments with bidding games have suggested that where this close familiarity with the situation being studied is absent, a source of bias may exist that could have substantial implications for some survey results. For example, one study in the program attempted to value visibility at the Grand Canyon National Park and in surrounding areas. One interesting result of the study was that the reported willingness to pay of respondents did not appear to diminish with distance – e.g., those surveyed in Chicago had fully as high a willingness to pay to protect visibility at the Grand Canyon in the initial survey as those who were questioned in Denver. In one set of later experiments, based on such a small sample that the results should not be regarded as anything but suggestive of hypotheses for future research, further bidding games were conducted in those two cities. In both cities, instead of being asked questions only about willingness to pay for visibility in the national parks, respondents were first asked about their willingness to pay for other, closer to home, environmental public goods. When this was done in Chicago, willingness to pay for visibility in the national parks dropped sharply below the result found in the previous survey. In Denver this was not the case, perhaps because the questions about visibility were less hypothetical to respondents in Denver; therefore their answer may have been better thought out than was the case for respondents in Chicago. In another set of experiments, again conducted with a highly inadequate sample because of limited resources, persons were asked first about their willingness to pay for a national improvement in water quality. Another sample was then asked about the same improvement in water quality plus an improvement in air quality. The resulting willingness to pay for both was about the same as the first group's willingness to pay for water quality improvement alone.

These kinds of highly experimental results have led members of the research team to speculate that people may have "mental accounts," one of which may be for environmental improvement. If that is the case, when they are asked about a hypothetical, but rather dramatic, environmental improvement they may allocate everything in their environmental account to it, neglecting alternative environmental improvements that, if confronted with them, they would also regard as valuable. An important further development in contingent valuation techniques will be to devise methods to structure them so as to avoid the one-issue-at-a-time procedure that has characterized most applications so far.

In conclusion, while I believe that the research reported here represents a significant improvement in our understanding of environmental-quality economic values, much remains to be learned. Total accuracy about a matter of this difficulty is an impossible dream, but I believe that the work done so far demonstrates that steady progress is feasible.

Comments by John Z. Swaigen

Economists have made major contributions to environmental thought and environmental law – for example, through the application of the concepts of externalities and cost internalization. Economists such as Ezra Mishan were among the first to point out that corporations are reaping the benefits of pollution and other forms of environmental degradation, while imposing the costs on the public at large. Ensuring that industry internalizes these costs is, and should be, a cornerstone of environmental law.

In two other areas, however, the field of economics has been less successful – in attempting to measure the costs and benefits of environmental control and in prescribing remedies for the problem.

Mr. Kneese has been frank in his paper about the limitations of cost-benefit analysis, and I shall not attempt to reiterate them. The most serious limitation, it seems to me, is that economics by its very nature cannot truly comprehend or measure the "intrinsic" value of nature. Economics must reduce the value of nature to a "market" value – a value for use by people. I question whether it can comprehend or measure purely spiritual values, or recognize the possibility that nature has value apart from the interests of man. Economics is determinedly "anthropocentric" rather than "ecocentric."

The remedies designed by economists – effluent charges, pollution taxes, and the sale of pollution rights – also have serious problems. Their effectiveness is generally based on a number of assumptions: that the industrial processes and economic positions of the polluting companies are comparable; that the capacity of airsheds and watersheds to assimilate pollution is known; that industries are discharging measurable quantities of a single pollutant, rather than a chemical soup; that the impact of pollution is uniform throughout the watershed or airshed where the pollution tax applies or the pollution rights are distributed; that there will be sufficient pressure brought to bear to ensure that the pollution charge will be set at a level that encourages reduction of emissions; and that the loadings to which the tax applies will be measured accurately.

I am not suggesting that the current legal framework does not suffer from the same shortcomings. My point is that given the shortcomings of both the economists' proposals and the current law – shortcomings such as the difficulties of proving causation, the synergistic effects of contaminants, and the difficulties of enforcement – there are obvious and pressing reforms to the current legal regime that will bear fruit more quickly than a shift in focus to economic measurement tools and economic remedies.

These fall into six categories: reform and enforcement of corporate law; more effective use of administrative instruments – e.g., orders and approvals; more effective sanctions; reform of the tort system; more public participation; and more resources for research, education, and enforcement.

Corporate law — Many provinces have laws requiring corporations to identify themselves when they carry on business transactions. But if corporations use names that are not registered, they are rarely prosecuted. Corporations are required to provide up-to-date and accurate information about changes in directors, changes in address, and other important matters. But they are rarely prosecuted for failing to do so.

In some jurisdictions, corporations are not even required to identify their shareholders. A corporation may be owned by underworld figures, and neither the public nor the government can find this out without going through costly procedures.

The problem is further complicated by foreign ownership of corporations. The Canadian managers of multinational corporations often have no authority to make the expenditures required for pollution control. The head office often will not authorize such expenditures until a dramatic incident occurs, such as a major spill.

More effective use of administrative instruments — Environmental laws are not primarily prohibitive and punitive. They are regulatory. The main instruments are not prosecutions, but regulation of potentially harmful activities through licences, permits, and orders. The licences and permits can be issued subject to terms and conditions. Appropriate conditions can prevent many unsafe practices. One condition that should be attached to many approvals and orders is a requirement to carry adequate insurance to compensate victims of pollution and to deposit financial security that can be forfeited for failure to carry out responsibilities, including the failure to construct and adequately operate and maintain required pollution control facilities, and the failure to pay fines levied by courts upon conviction for offences.

More effective sanctions — When polluters break the law, frequently the only deterrent available to courts is to impose a fine. Not only are the maximum fines too low under many statutes, but fines are not always the most appropriate sanction. Greater attention should be given to the development of sanctions such as community service orders, orders to rectify the underlying causes of the pollution, orders to publicize the conviction, orders to compensate victims, imprisonment of offenders, and a variety of other innovative sanctions.

Reform of the tort system — When government prosecutes polluters, conviction results in a fine that goes to government. To receive compensation for harm, individuals usually must hire their own lawyers and experts to sue the person responsible. The cost, psychological stress, delay, and difficulties in proving a causal relationship between their injury and the actions of the defendant frequently make success impossible.

An alternative institutional arrangement is needed that will not pit the victim against large corporations in adversarial proceedings. Part IX of Ontario's Environmental Protection Act, the "Spills Bill," is one such alternative.

More public participation — The rights of citizens to have access to the legal system are far more limited in Canada than in the United States. Reforms that would increase public access include: standing to sue in public interest cases; class actions; public consultation before standards of environmental quality are established by government agencies; freedom of information legislation; and "whistle-blower" laws that protect employees from harassment for reporting violations or refusing to carry out illegal work.

More resources — The effective enforcement of environmental laws requires more and better trained and better equipped inspectors, investigators, and scientists, as well as more education of industry about the laws and the appropriate standards of conduct. All of this costs money that governments have not been prepared to spend. Without this, environmental agency incompetence is a self-fulfilling prophecy: understaffed agencies cannot act effectively; they are therefore constantly attacked by the media and the public; their morale suffers; and they consequently become even less effective.

Comments by Elizabeth A. Wilman

Allen Kneese, in his paper, discusses the application of benefit-cost analysis to some of the important and complex environmental issues of the day. As he suggests, there are serious conceptual and quantification problems in applying this tool. These range from difficulties in the measurement of changes in the levels of environmental services, to issues in the quantification of benefits and costs, and to questions of how to deal with extremely long-lived effects that may extend many generations into the future. As our discussions of yesterday and today have indicated, one does not need to look far for examples. Toxic substances and acid rain both contain some of these problems. After mentioning these important conceptual and quantification problems, the paper then focuses on one body of research methods developed for improving the quality of information that can be brought to bear on such problems – the contingent valuation method.

I would like to make a couple of comments on the use of the CV method in measuring environmental damages, and then go on to discuss a second but related issue concerning the use of cost-benefit analysis – that of making decisions in the presence of considerable uncertainty with respect to environmental damages.

In some of the other sessions, we have heard recommendations for pricing water and other resource services. What the CV approach is intended to do is to confront the individual with a hypothetical market situation and have him respond in such a way as to reveal his willingness to pay (WTP) to avoid the loss of the service or his willingness to take compensation (WTTC) in return for the loss of the service, where the service may be air quality, water quality, or recreational opportunities.

Such questions are inevitably hypothetical to some degree, and thus there is the possibility for response errors in the form of bias (a lack of validity) and/or of large response errors (a lack of reliability). Much of what Allen Kneese discusses has to do with methods to overcome bias and reliability problems. The water quality ladder and the payment card are ingenious approaches.

However, bias and reliability problems are not totally solved. One of the things we need to worry about more than we do is validity. A measure is valid if it measures what it is intended to measure. There are a number of different types of validity that can be important when using survey research techniques to measure attitudes or behaviour. Four are useful for our purposes. These are:

1) Predictive validity: Do responses predict future actions?

2) Concurrent validity: Do responses correlate with performance measured at the same time?

3) Content validity: Does the question bear a reasonable relationship to the content of the concept to be measured?

4) Construct validity: Do responses correlate well with other variables with which one would theoretically expect them to be correlated?[2]

The best way to test for validity is, of course, by comparison with actual behaviour. If current behaviour comparisons are made, this is a test of concurrent validity. If future comparisons are made, it is a test of predictive validity. Neither is necessarily preferred. It is simply a matter of what is appropriate, given the goals of the study.

Validation is very difficult for WTP estimates because comparison with actual behaviour is seldom possible. Bishop *et al.* (1983) have made the only such comparison in the literature.[3] They find WTP estimates to be biased downward and WTTC estimates to be biased upward. Other studies [Brookshire *et al.* (1982)] have attempted a form of construct validity, comparing WTP and WTTC estimates with estimates obtained via the hedonic and travel cost approaches.[4] In general, the conclusion is the same.

The other way of testing for bias involves varying elements of the structure of the question that are suspected sources of bias. However, the problem with this approach is that the content of the question is being changed. If the content of the question is changed, the responses might be expected to change legitimately. The change in the responses need not be evidence of bias. On the other hand, if the responses do not change, there may be reason to question whether the content of the question is appropriate.

If we want to use WTP and WTTC questions to measure the benefits or costs associated with changes in environmental services, it is necessary that we make a greater effort to validate the responses to such questions.

A second issue that arises with hypothetical questions is reliability. Repeated responses will show a variance around a mean or expected value that is the correct measure of WTP. If this variance is large, the WTP estimate will be unreliable. WTP researchers have inappropriately dubbed this a "hypothetical bias." In fact, there need be no systematic bias, only a lack of reliability. In other disciplines, such random error in the responses to questions is dealt with by multiple items, or repeated measurements. Each item has random error, but over enough items these errors cancel out. This is something we have not tried in WTP studies. Some would argue that given the complexity of WTP questions, multiple questions would be completely unfeasible. Perhaps we need to give some consideration to being less pure for any given question and to asking more questions.

A related, but little investigated, problem that one might expect to arise with respect to large response variances is heteroscedasticity. There is no reason to expect response variance to be constant across all groups in the population. In fact, the incidence of nonresponses to WTP questions suggests that groups that have less education and/or less experience with the environmental service being valued, have more trouble answering WTP questions. In addition to the greater proportion of nonresponses, one would also expect these groups to have larger response variances. Hence heteroscedasticity may result, and when the WTP estimates are used as dependent variables in regression analyses, the estimates of the variances of the regression parameters will be biased. As a result, statistical tests and confidence intervals based on these variance estimates will be incorrect. The more hypothetical the question, the less reliable will be the estimates obtained, and the greater the potential for heteroscedasticity. If WTP estimates are to be believable, it is important that they be as reliable as possible and that observations be weighted to correct for heteroscedasticity.

Finally, a problem with using the hypothetical market approach of CV is that the markets set up in the questionnaire are second-best markets in that they internalize only one of many externalities. As Allen Kneese suggests, the one-at-a-time procedure that has characterized most applications of the CV approach may be inappropriate. However, it is clear that it would be impossible to pose a hypothetical market that would internalize all externalities. What seems to me to be a sensible approach is to introduce a number of questions that make the individual aware of a wide range of environmental services; how he pays for some of them in terms of higher consumer prices, higher electricity bills, or whatever; and how, if others are to be provided, he may also have to bear some of the cost.

I do think the CV approach has an important role to play in improving the information base upon which environmental decisions are based. We do have to worry more about proper validation, and we do need to improve reliability, but considerable progress has already been made, and further research can yield more improvements. One of the reasons that I think CV estimates should continue to be pursued is that, with environmental problems being given more media coverage, I think people are becoming more aware of what environmental pollution can mean in terms of damages to themselves. In addition, I think there is an increasing realization that a clean environment can only be obtained by giving something up. As awareness of both the benefits and costs of environmental quality improvements increases, the CV approach should become more meaningful and less hypothetical. In addition, as has been suggested by Allen Kneese, for some intrinsic benefits there may be no alternative.

Although we should certainly make every attempt to improve our knowledge of the linkages between discharges into the environment and environmental damage and to quantify the damages, it is clear that we cannot have perfect information and that we must make decisions based on imperfect information. Even indecision or delay in addressing a particular pollution problem is, by default, a decision.

Decisions based on imperfect information can, of course, turn out to be wrong in retrospect, and there are costs to being wrong. However, what we need to concern ourselves with is the cost of being wrong, or as was suggested in an earlier session, minimizing regret. For a number of the environmental problems we face today, there is reason to expect that the costs of being wrong are greater if we do little or nothing to reduce the pollution than if we impose too-strict controls on the polluters. Acid rain and toxic substances are two problems for which the above statement is likely to be true. The long-term and potentially irreversible damages warn us of that eventuality. The stricter controls can preserve our options. If stricter controls are imposed and, at the same time, research is carried out to improve our information about potential damages, it is possible to relax the controls at some time in the future should damages prove negligible. For these kinds of examples the reverse case is harder to make. If weak regulations lead to irreversible damage, strengthening them will not rid us of the damage. It is also true that, as a society, we might be expected to be risk-averse with respect to irreversible damages. In cases where we are talking about potentially large, long-term, or irreversible damages, but where environmental damages can be measured with little certainty, it makes sense to take a conservative stance and impose strict regulation, unless (and until) it can be shown that the benefits of such regulation do not exceed the costs. Although it would not be sensible to require that this be shown with certainty, the standard of proof should vary with the magnitude of the potential damage.

To conclude, I think it is important to press two points. First, as Kneese has stressed, there has been considerable progress made in the estimation of environmental damages through the CV approach. But there are more questions to be answered. This work, and all research related to environmental damage estimation, must continue to go forward. However, decisions cannot wait for perfect information. In cases where the potential damages are large, long-term, or irreversible, there is reason to take a conservative stance and impose stricter rather than weaker regulations. Although this will impose costs on the polluters and on society, they may in the long run be less than the alternative.

Floor Discussion

Question: *An explicit weighting of the costs and benefits is preferable to decision making where weightings remain implicit. In developing environmental policy, however, should cost-benefit analyses be the only input?*

A. Kneese: We can apply cost-benefit analysis to try to measure intrinsic economic values – that is, values held by people in economic terms that do not directly benefit them in the conventional sense. But I do not argue that every kind of ethical view about appropriate behaviour can be encompassed in the utilitarian framework of economics. For areas where noneconomic goals may be quite prominant in peoples' minds, I advocate a limited role for cost-benefit analysis. In such cases a test can be applied: Do the measured economic benefits exceed the costs of an environmental program? If they do, then there is a good case for proceeding. If not, then the political process has to make the decision based on whatever ethical views people may bring to it, whatever interests they represent, as well as on the economic information.

Question: *We consider the benefits of environmental protection, but we also need to examine the employment and income consequences of actually realizing those benefits. Has there been research on these consequences?*

A. Kneese: In the United States there has been some research, and one can say with a considerable degree of confidence that environmental programs have not had a strongly negative effect on the macroeconomic performance of the economy. The effects probably are slightly positive in terms of employment and slightly negative in terms of real output and productivity, as these are conventionally measured. But there is a serious measurement problem. By far the greatest benefits from environmental programs accrue directly to consumers and not to industry. Whatever utility flows directly to people is not measured in the market and so is not included in conventional accounts.

9 Addressing Environmental Issues in the Future

Presentation by James Gustave Speth

Today a new environmental agenda is emerging, and it is forcing itself on the attention of policy makers in the United States, Canada, and other OECD countries.

The concerns of the new agenda encompass the great life-supporting systems of the planet's biosphere – the atmosphere, oceans, climate, soil, and forests. These issues are arising from the spread of deserts, the loss of forests, the erosion of soils, the growth of human populations, the exhaustion of ecological communities, the accumulation of wastes, and the alteration of the biogeochemical cycles of the planet. These newer concerns tend to transcend borders, national laws, and local customs. As a result, the politics needed to meet present and future challenges require a new vision and a new diplomacy, new leaders, and new policies.

Of course, the predominately local or strictly national issues of the past decade will not disappear. These established issues are still important, still much in need of attention. The efforts launched in the 1970s to control local pollution; regulate hazardous substances and protect drinking water; curb stripmining and clearcutting; manage fisheries; regulate offshore drilling and coastal development; and protect parks, wilderness, wetlands, and wildlife have been only partially successful. Much more needs to be done in these areas in the United States, Canada, and elsewhere.

But we must also make room for the new agenda. There are many compelling reasons for a high level of concern and response: reasons of humanity, of environment, of science. But, increasingly, we are seeing that how the new agenda is addressed can profoundly affect the economic and security interests of the industrial countries. The new agenda will demand attention in the 80s and 90s in part because its concerns are inextricably linked to other pressing international goals:

- expanding international trade and markets,
- improving North-South relations,
- promoting sustainable economic development,
- managing the pressures of population increases, and
- ensuring long-term political stability in the Third World.

In a world that is daily more complex and interdependent economically, the economic and security interests of the industrial countries must be understood in a broad global context. Economic problems elsewhere in the world – for example, those stemming from food, resource, and population pressures – can affect such OECD concerns as economic recovery and international political stability. Private and public decision makers must together attend to these emerging issues.

The New Agenda

Consensus seems to be emerging, within the international scientific community and among other experts, on exactly what are the priority environmental, resource, and population problems, at least given the current state of our information and understanding.

In 1982, the Royal Swedish Academy of Sciences convened a week-long international gathering of scientists to look at environmental priorities for the 1980s. At least 40 issues had been targeted ahead of time for serious consideration, and one goal of the meeting was to trim this to a short list of front-ranked items.

More recently, 75 leaders from science, business, government, and environmental affairs representing 20 countries were brought together for several days by the World Resources Institute for a conference entitled "The Global Possible: Resources, Development and the New Century." Again, a goal was to identify key concerns of global scope and what to do about them.

These two exercises produced very similar results regarding priority concerns – results that have been reached by others as well. Both efforts identified the following problems as truly serious and deserving of wide international attention:

1. Loss of crop and grazing land due to desertification, erosion, conversion of land to nonfarm uses, and other factors. The United Nations reports that, globally, farm and grazing land is being reduced to zero productivity at a rate of about 20 million hectares a year. (One hectare equals about 2.5 acres.)

2. Depletion of the world's tropical forests, which is leading to loss of forest resources, serious watershed damage (erosion, flooding, and siltation), and other adverse consequences. Deforestation is projected to

claim a further 100 million hectares of tropical forests by the end of this century.

3. Mass extinction of species, principally from the global loss of wildlife habitat, and the associated loss of genetic resources. One estimate is that more than 1,000 plant and animal species become extinct each year, a rate that is expected to increase.

4. Rapid population growth, burgeoning Third World cities, and ecological refugees. The world population will most likely double by the early decades of the next century, and almost half the inhabitants of developing countries will live in cities – many of unmanageable proportions.

5. Mismanagement and shortages of fresh water resources. It now seems possible to many researchers that water will be to the 1990s what energy was to the 1970s.

6. Overfishing, habitat destruction, and pollution in the marine environment. Twenty-five of the world's most valuable fisheries are seriously depleted today due to overfishing.

7. Threats to human health from mismanagement of pesticides and hazardous substances and from water-borne pathogens. Water-borne diseases are responsible for about 80 per cent of all illness in the world today.

8. Climate change due to the increase in "greenhouse gases" in the atmosphere. The steady build-up of carbon dioxide and other gases in the atmosphere, due principally to fossil fuel burning, is predicted to create a "greenhouse effect" of rising temperatures and local climate change – the question increasingly is not "if?" but "how much?"

9. Acid rain and, more generally, the effects of a complex mix of air pollutants on fisheries, forests, and crops. The "export" of acid rain, for example, harms not only natural resources but also constructive relationships among neighbouring states in political and economic affairs.

10. Mismanagement of energy fuels and pressures on energy resources, including shortages of fuelwood, the poor person's oil. Although market forces and government actions have eased pressures, these vital resources are, undeniably, finite in quantity and disparate in locale. Our energy problems may be forgotten, but they have not gone.

It is instructive to reflect on this list. Taken together, these 10 problems mainly stem from either excessive poverty and population growth in the developing countries or from the careless and excessive use of certain technologies and resources in the industrial countries. While the industrial countries are affected by most of these problems, the cumulative impact of these threats is far more serious in the poor countries than in the rich. Yet, because of their wealth, technology, and an ability to exercise international leadership, the rich countries are far more able to do something about them.

Another point to note is that these 10 problems are not, by and large, the environmental concerns to which the industrial countries turned priority attention in the early 1970s. While many of these problems have been recognized for some time, they represent a new policy agenda for the industrial countries, one that has emerged since the early 1970s, one that is more international and global in its scope and implications and is concerned more with management of economically important resources than with traditional pollution control.

A Common Ground: New Politics

In the United States, about which I can write with more certainty, the politics of this new agenda are different from the environmental politics of the past decade. In the United States, predominantly domestic environmental causes of the 1970s had little going for them but the people. The environmental movement handed the business community a long string of defeats; it left the scientists anxious in their efforts to keep up. Economists were aghast; ecologists, even lawyers, were lionized. Citizens took on government at all levels, and won. Large majorities of the public were strongly pro-environment – and they still are, as the Reagan administration learned the hard way.

The politics of the new agenda, on the contrary, must be a search for common ground. Popular support for the new agenda is now weaker than for the old: the issues are more remote, more distant in space and time. Although there are conspicuous exceptions (like acid rain), the new agenda addresses the relationship of environment and development in the Third World, the health of the global commons, and a series of resource and environmental threats that, while serious, are less visible, often slow to develop, or affect the United States only indirectly. But as if to compensate, the new agenda invites strangers and even old antagonists to work together. Economic growth is needed to attack poverty, the worst destroyer of the environment worldwide, so business and labour leaders and environmentalists must make common cause in promoting sustainable growth. Economists and ecologists must cooperate if development strategies are to promote this goal. The development, population, and environmental communities now face the same set of problems. The relevant bureaucracy in national and international agencies – now almost immune from litigation and able to cloak itself in the mysteries of foreign policy and national security – must be wooed on its own terms. Yet, it too will not succeed unless it comes to terms with global-scale resource, environmental, and population issues.

The New Agenda and the Economy

The emergence of the new agenda has been accompanied by a growing realization that the goals of environmental conservation and economic growth in both developing and industrial countries are more complementary than often depicted. Most of the resources under stress today are vital to healthy, long-term economic development and growth. A. W. Clausen, president of the World Bank, has described these relationships:

> There is increasing awareness that environmental precautions are essential for continued economic development over the long run. Conservation, in its broadest sense, is not a luxury for people rich enough to vacation in scenic parks. It is not just a "motherhood" issue. Rather the goal of economic growth itself dictates a serious and abiding concern for resource management.[1]

Similarly, the conservation community is increasingly aware that resource pressures in developing countries will not be alleviated without the economic growth necessary to provide people with nondestructive livelihoods. Some of the worst environmental destruction occurring today stems from the impact of poverty on the land.

One important way the economic future of developed countries is linked to global resource, population, and environmental problems is through the effects that these problems have on economic development in the Third World. To state the matter simply, the better resource and population challenges are managed in the developing countries, the greater the prospects for sustainable economic development in those countries. And sustainable development means a greater boost for developed economies.

In the *Interfutures* study of the Organisation for Economic Co-operation and Development, the OECD countries showed higher rates of economic growth and progress under the scenarios in which the developing countries fared better also.[2] Presumably, the largest effect here is that of expanding markets for OECD countries, but the OECD has noted many linkages:

> In 1976, investments by OECD countries such as Canada, Germany, Netherlands, Sweden, the U.K. and the U.S. in Third World countries represented about 25 per cent of their total foreign investments. In the case of Japan, the figure was 55 per cent. During the same year imports from developing countries represented 28 per cent of total imports of OECD countries, while exports to developing countries represented 23 per cent of all exports. Around 29 per cent of all primary product imports by OECD, excluding fuel, originated in developing countries which, in turn, received 26 per cent of all OECD exports of manufacturers.[3]

In light of these growing economic ties, resource and environmental degradation in developing countries – including the failure to find attractive substitutes for high-cost energy imports, to manage renewable natural resources for sustainable production, and to protect public health from environmental diseases – can affect our economic performance adversely.

As the OECD observes:

> The growing scale of issues such as the loss of genetic materials, the conversion of cropland, soil degradation and tropical forest destruction, and the inability of many Third World countries to deal with them, could have serious economic and even security consequences for OECD Members.[4]

An especially bleak developing-world scenario depicts a future in which resource, environmental, and population problems are not addressed and economic development lags. In this scenario, a vicious cycle involving people, poverty and resources is prevalent. Poverty grows, as does the gap in per capita income between rich and poor. Frustration, resentment, and even civil strife mount. In such an atmosphere, the industrial world finds itself buffeted in many ways: pressures for foreign assistance and humanitarian concessional aid increase, as do the expenditures needed to sustain military readiness in many parts of the world; the industrial countries are faced with a variety of hostile economic acts: nationalization, debt cancellation, cartels, boycotts, closing of markets. Destabilization and civil turmoil make trade and successful economic ventures impossible or less likely, and the "Western model" and free institutions come under increasing pressures as authoritarian measures become more attractive to governments struggling to cope.

Growth cannot flourish in an atmosphere of political instability. Whether a future that is hospitable and favorable to investment and trade emerges depends, in part, on the seriousness and concern with which global-scale resources, environmental, and population problems are addressed.

Beyond a general interest in the global sustainability of natural resources and the development that depends on them, business has both direct and indirect reasons to care about specific environmental and resource-management issues. There are, of course, direct economic consequences for certain sectors of domestic and international commerce: the price and availability of oil, for example, or the marketability of food sprayed by certain pesticides. But indirect consequences are also important: the geopolitical effects of irrigation and fishing practices, for example, or the effects on agriculture of climate change caused by the buildup of carbon dioxide (CO_2) in the atmosphere.

In several ways, global-scale resource depletion and environmental degradation can create significant costs or risks for our economies and for particular commercial sectors.

Climatic resources — The most troubling aspect of the global warming that may already be occurring as a result of the buildup of CO_2 and other "greenhouse gases" in the atmosphere is not the warming *per se* but the large-scale disruption of the global weather machine. This disruption stems from the differential warming that could occur: very slight at the equator, very significant at the poles. The change in weather patterns in the agricultural regions could be significant.

The "greenhouse" theory and models were once thought to be speculative, even after the steady increase in atmospheric CO_2 had been well documented. But recent scientific reviews have found no reason to doubt the theory, and some evidence suggests that a warming is already under way.[5] The consequences are still thought of as occurring in the distant future. The problem with that view, however, is that the lead time needed to plan and execute a response – whether prevention or adaptation, or both – is necessarily long. Clearly, we should be coming to grips with this problem now, while we can do something about it.

Fishery resources — Much of the world's population depends on fish for food and protein, and the global fisheries support a large industry in both food and industrial products. Thirty-two countries receive one-third or more of their animal protein from seafood, according to the United Nations Environment Programme, and another 11 consume twice the world per capita average.

The harvesting of fish has increased dramatically in this century. Between 1900 and 1962, the total catch from marine and fresh waters rose by a factor of eight. Between 1948 and 1967, production from marine fisheries tripled, to about 65 million tonnes (metric tons). This growth then slowed remarkably in the 1970s, and the yields of some fish have declined, principally because of overfishing and environmental factors.[6] Also, locally important fisheries are showing signs of serious stress. Many observers believe that the harvests of traditional fisheries are not likely to increase greatly on a sustainable basis, and some catches may already exceed the sustainable yield.

It seems clear that we have reached the point where preserving this major food source and the industries that depend on it requires careful national and international supervision and improved protection of the marine and fresh-water environments. Natural environmental threats, such as shifts in the Humboldt Current, are seriously compounded by inadequate management and overfishing, man-made pollution, and changes in fish habitat created by land development and other factors. Meeting world food needs and satisfying our demand for seafood will require careful attention to these problems.

Moreover, I need not describe for this audience the damages that acid rain causes to inland, fresh-water fisheries.

Genetic resources — Scientists estimate that between 5 million and 10 million plant and animal species now live on earth, and there is wide agreement that the current extinction rate for these species is both high (perhaps 1,000 species a year) and rising.[7] Wild species are commonly thought to be important for their aesthetic and scientific value – evidence of a diverse and creative nature. But species are also important economically. Species and genetic resources provide new sources of food, materials for energy and construction, chemicals for pharmaceuticals and industry, and natural pest controls, as well as the basis for adapting to climatic variability and other broad environmental changes.

According to Norman Myers, an ecologist who has studied the monetary significance of wild species, the routine infusion of wild germplasm into agricultural crops increases productivity value by as much as $1 billion a year in the United States, and similar gains are common in Canada and the Soviet Union. In four specific examples: sea urchins produce holothurin, which may save thousands of lives by correcting coronary disorders; octopi secrete an extract that relieves hypertension; Caribbean sponges produce an antiviral compound; and shellfish skeletons are the source of an enzyme that protects medicine from fungal infections.

Myers estimates that the U.S. market value of drugs and pharmaceuticals derived from plants is $20 billion a year. Conversely, the loss of species with potential for medical products might be costing humanity more than $200 billion a year in unrealized healing. He considers this calculation conservative, since it rests on the assumption that species loss will continue at current levels, whereas it may be accelerating.[8]

Ironically, the current loss of species (which is largely associated with deforestation in the tropics) is occurring just as the techniques of genetic engineering make it easier to utilize genetic resources for the benefit of mankind.

Agriculture and forests — The lands used to produce food and fiber crops in the United States and elsewhere are now under many pressures: conversion to nonagricultural uses, soil erosion, salinization, compaction and water-logging, declining groundwater tables, and the spread of deserts. One recent estimate put the average annual loss of agricultural land globally at 8 million hectares from nonagricultural conversion, 3 million hectares from erosion, 2 million hectares from desertification, and 2 million hectares from toxification.[9] U.S. and Canadian agriculture is certainly not immune from these disturbing trends, although continued domestic productivity increases can compensate, at least for a period, for problems that are more apparent elsewhere in the world.

Another environmental problem, air-borne pollution, can harm crops and forests in addition to posing health hazards. Ozone is formed by photochemical reactions with the exhaust from fossil-fuel combustion. A recent survey of four U.S. crops by the congressional Office of Technology Assessment estimated annual losses from ozone damage at perhaps $3 billion.[10] This survey showed a loss of about 5 per cent in wheat, corn, soybean, and peanut harvests.

Commercial forests in many areas in the Northern Hemisphere are believed to have been damaged by air pollutants, including acid rain. In West Germany, for example, 55 per cent of the forests have been adversely affected, according to a 1984 Ministry of Agriculture survey.[11] As a result of this evidence, acid rain politics in West Germany have changed dramatically. Data on damage to U.S. Eastern forests is also beginning to accumulate. The cause of damage has not been clearly established in any of these regions, but some combination of acidic deposition, gaseous air pollutants (ozone, sulfur dioxide, and nitrogen oxides), and drought is thought to be responsible. What is clear is that observed forest damages are widespread and that they have increased rapidly in severity and geographical extent.

These examples could be supplemented by many others. Cumulatively, they suggest that major sectors of our economies have a significant stake in the protection of the planet's increasingly pressured renewable-resource base. In each of these areas, there are remedial actions that should be carefully considered, and both public and private sectors have major roles in finding appropriate answers.

These resource issues present both business and labour with both opportunities and challenges. One opportunity is to address this new set of more global resource questions as active leaders, thus avoiding the confrontation and adversary style that often was the hallmark of U.S. domestic environmental politics in the 1970s. Global environmental issues can be handled in a way that allows both practical commercial considerations and good citizenship to motivate a greater leadership role for business and labour.

The New Agenda and Foreign Policy

Beyond economic concerns, there are many ways in which the foreign policy interests of the industrial countries are linked to global-scale resource, environmental, and population issues.

In justifying its call for concerted national and international action to address the issues on the new agenda, the statement issued at the Global Possible Conference stressed that:

> International security is at stake too. There will be many more people on this earth soon. Without the changes urged here, a large portion will join the legions who already live with constant hunger, illness, and illiteracy. If we allow their numbers to grow, if we allow economic development that is unsustainable, and the pressures of people on resources increase, political tensions and conflicts will rise. The effects will be felt in every sphere of political relations, from waves of "ecological refugees," to conflict over scarcer land and water, to increasingly isolationist trade and then foreign policies.[12]

Typically, "national security" has been interpreted in almost exclusively military terms. Given the linkages among population, resource, economic, and political factors, a broader concept of long-term security interests is essential for the decades ahead.

Environmental degradation in developing countries affects foreign policy interests in many ways. Consider these examples:

Haiti, where burgeoning population growth combined with extreme poverty has resulted in massive denudation of the forest and other vegetative cover, extreme erosion, and reduction of the agricultural productivity. What appeared initially to be a Haitian problem has become a domestic U.S. problem as environmental conditions have helped force thousands of Haitians to seek refuge in the United States, as well as requiring ever larger amounts of U.S. foreign assistance.

Bhopal, India, where a gas leak at the Union Carbide pesticide plant killed some 2,000 people and injured over 50,000. While the cause of the accident is still under investigation, the event has triggered significant anti-American feeling in India along with public demands for compensation, legal action against the U.S. company, and concerns about the operations of U.S. companies in many countries.

The Sahelian Zone of Africa, where widespread starvation of people and livestock devastated large parts of the nations along the southeastern edge of the Sahara in 1972. Inadequate and ill-planned development projects had led to an increase in both human and livestock populations to the point where, under the best conditions – in years of high rainfall – they met or exceeded the carrying capacity of these ecologically fragile lands. Then, when drought conditions (a normal event in these areas) came, the result was mass starvation. Because of the magnitude of the disaster, a cooperative international assistance of effort was mounted, and the United States alone has spent billions of dollars for famine relief and rehabilitation in the region. Yet, many of the same development assistance mistakes have been made, the same environmental degradation problems remain, and ever greater amounts of assistance are required.

Ethiopia, where too many people struggling for subsistence have overused and degraded the land to the point where it can no longer support them. The result is, again, massive starvation, with the United States providing millions of dollars of emergency food supplies. Yet, while this assistance is needed for humanitarian purposes, it does nothing to solve the underlying problems of environmental degradation. And there are similar problems, throughout much of the rest of sub-Saharan Africa, of continuing uncontrolled population increases and degradation of soil, vegetation, and other environmental resources. Unless development assistance focuses effectively on improving these countries' capabilities for environmental and resource management and population control, there will be increasing malnutrition and starvation, as well as economic, political, and military unrest.

El Salvador, where population pressures and an extremely degraded environment have contributed to an international military crisis. The present U.S. military and financial involvement in Central America started in El Salvador with the United States assisting the government against guerrillas. A 1982 draft report commissioned by the U.S. Agency for International Development (AID) described El Salvador's extremely degraded environmental conditions and concluded that the "fundamental causes for the present conflict are as much environmental as political, stemming from problems of resource distribution in an overcrowded land."[13]

These developing country issues are of importance to the United States and other OECD countries for many reasons. It is fair to say that their long-term economic, political, and even military interests depend far more than has been generally acknowledged on the success with which developing country resources can be wisely managed for sustainable development.

Cornucopians and Malthusians: A New Synthesis?

The past decade has been notable for a number of transitions or shifts in thinking about environmental and resource issues, three of which have already been discussed: the shift from concern principally with issues of traditional pollution control to broader issues of resource management; the shift from a nearly exclusive focus on local problems to a growing concern with long-distance, transnational, and now global concerns; and the shift in developing countries from viewing the environment as a rich man's issue to growing recognition that environmental conservation and economic development are complementary processes.

But the past decade has also produced another important transition, a transition in thinking about the future. The story begins with the first broad recognition of planetary limits – of the unsustainability of certain types of exponential growth.

The Limits to Growth, a 1972 report to the Club of Rome's Project on the Predicament of Mankind, was the first of several studies to gain popular attention.[14] It concluded that world resources are finite, and that if industrial expansion, population growth, and pollution continue unchanged, the most probable results would be a sudden, uncontrollable decline in population and industrial capacity within a century. Among its solutions to what it saw as impending world crises were curtailed economic expansion in some regions, population control strategies, and a search for renewable energy and food supplies.

Lester Brown's *The Twenty-Ninth Day*, argued in 1978 that the earth's "carrying capacity" was threatened by ecological stresses that could only be eased with conscious political and social decisions that took account of the earth's expanding problems. The title recalled a French riddle used to teach students about the concept of exponential growth:

> A lily pond, so the riddle goes, contains a single leaf. Each day the number of leaves doubles – two leaves the second day, four the third, eight the fourth, and so on. "If the pond is full on the thirtieth day," the question goes, "at what point is it half full?" Answer: "On the twenty-ninth day."[15]

And *The Global 2000 Report to the President*, an ambitious technical study requested by President Carter in 1977 and released in 1980, predicted that, "If present trends continue, the world in 2000 will be more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now. Barring revolutionary advances in technology," the report concluded, "life for most people on earth will be more precarious in 2000 than it is now – unless the nations of the world act decisively to alter current trends."[16]

These and similar studies were quickly labeled by critics as "doom and gloom" products of the Malthusian persuasion. Although these studies typically offered hope that concerted action taken today could forestall or prevent problems projected for tomorrow, the message picked up in the media and conveyed to many readers was one of pessimism about the future. Warnings about what *could* happen were widely interpreted as predictions of what *would* happen. By dwelling on future risks and failing to sketch an attractive, realizable future and measures to achieve that future, some studies undoubtedly contributed to this unfortunate result.

The critics of these studies thought they saw a number of faults: a "no-growth" economic disposition, a renunciation of human ingenuity, and a preference for government over the forces of the free market. One major work, *The Resourceful Earth: A Response to 'Global 2000'* parodied *Global 2000* in an "executive summary" that promised, with ample italics:

> If present trends continue, the world in 2000 will be *less crowded* (though more populated), *less polluted, more stable ecologically*, and *less vulnerable to resource-supply disruption* than the world we live in now. Stresses involving population, resources, and environment *will be less in the future than now*.... The outlook for food and other necessities of life will be *better*.... life for most people on earth will be *less precarious* economically than it is now.[17]

Paul and Anne Ehrlich note in a recent review of *The Resourceful Earth* that "various devices are used to reach this astonishing conclusion, including misdefining the problem, selective use of data, analyses of time series over inappropriate intervals, and determined ignorance of the most basic tenets of science. Indeed, the book contains so many childish errors that it would take a work of equal length to detail them."[18]

Perhaps with this volley, the Malthusian vs. Cornucopian debate of the last few years can now shift to practical alternatives. Surely the Global Possible Conference of 1984 represented an effort to move beyond this debate, which some believe is becoming increasingly sterile. The statement issued by the conference addressed this subject in its opening passages:

> At a time when bleak predictions are all too familiar, the Global Possible Conference was convened to re-examine the relationship between earth's resources and the human future. The Conference accepted that these predictions could be accurate. But its central and emphatic message is that they need not be – that it is possible to build a world that is more secure, more prosperous, and more sustainable both economically and environmentally.
>
> ... We must mobilize now to achieve the global possible. If we do, the future can be bright. We have sufficient knowledge, skill, and resources – if we use them. If we remain inactive, whether through pessimism or complacency, we shall only make certain the darkness that many fear.[19]

The conference participants (about half of whom were from the United States) were unanimous in the view that the challenges of the new agenda deserved sharply increased attention from governments, the private sector, and others. As grave as our resource and environmental problems are, the Global Possible Conference agreed, the challenges *can* be met with means that are within our grasp. The group proposed 94 specific steps for public and private sectors alike which can make a difference.

The conference's recommendations point to five transitions essential to a world at once sustainable and renewed: 1) a demographic transition to a stable world population; 2) an energy transition to an era in which energy is produced and used at high efficiency without aggravating other global problems; 3) a resource transition to reliance on nature's "income" and not depletion of its "capital"; 4) an economic transition to sustainable growth and a broader sharing of its benefits; and 5) a political transition to a global bargain grounded in complementary objectives between North and South.

From Agenda to Action

As the last decade has demonstrated, even *recognizing* the nature and scope of problems can be demanding. The next step, *resolving* them by prescription and action, presents different challenges that are even more demanding.

Defining, directing, and empowering responses will require careful and creative policy analysis. Fortunately, some of the needed analysis is now under way, and, as noted, progress is being made. Let me cite some examples from the United States with which I am familiar. The Global Possible Conference made several recommendations (such as those promoting the nonsubsidized pricing of energy, water, and pesticides), which have been suggested to Congress for its consideration.[20] The Global Tomorrow Coalition, a group of about 100 environmental, energy, resource, and population groups, has developed a list of legislative priorities that address the new environmental agenda. Environmental scientist Lee M. Talbot has prepared for the Environmental and Energy Study Institute an original and timely framework for Congressional action that addresses many current concerns. Among them: assuring that environmental considerations guide intergovernmental assistance decisions; strengthening developing-country environmental institutions and personnel; promoting monitoring and assessment of global environmental conditions, trends, and needs; assisting developing country research and development needs; and providing incentives and disincentives to cope with industrial hazards and toxic exports.[21] And there is new Congressional interest assuring that multinational development banks pay more attention to environmental and resource issues when they select and support developing-country projects.

Apart from Congressional initiatives, a major effort is now underway involving international development-assistance agencies, developing-country leaders, and private organizations to devise an action strategy to deal with tropical deforestation. Other efforts are now in progress to elucidate policy options for addressing problems associated with the use of pesticides, the loss of biological diversity, and other issues.[22]

In the private sector, too, there is a new awareness of environmental concerns and consequences. A panel of multinational business executives last year proposed specific steps that companies and their host and home governments could take to alleviate environmental and resource stresses in the Third World while also promoting sustainable economic development.[23] As the tragedy at Bhopal has demonstrated, international cooperation on this front is more necessary than ever.

These are all positive, constructive signs that the awareness gained during the past 15 years has sown seeds. The new environmental agenda is not only at hand, there are early signs that it is being put to use in ways that will, indeed, make our future brighter.

[The author would like to thank William Lanouette, Douglas Lea, Jessica Mathews, Robert Repetto, and Lee Talbot for their helpful reviews and suggestions.]

Comments by James P. Bruce

It is a great pleasure to be at this meeting sponsored by the Economic Council of Canada – where the brickbats are thrown not at the weatherman but at the economist. But meteorologists and economists do have much in common. We both make public predictions of events in very complex systems – although I am convinced that forecasts of the meteorologists are right more often than those of the economists. But we meteorologists do not have human intervention in the system to contend with on a day-to-day basis – only in the long term where, as Dr. Hare has already outlined, man's intervention in changing the chemical composition of the global atmosphere – i.e., polluting it – will probably lead to profound climatic changes within the next half-century.

Gustave Speth has, in his paper, delineated very effectively the major global environmental issues now and in the future, all resulting from man's intervention in the complex geochemical and biological system of this small planet. The issues are complex politically, economically, and scientifically, in part because they are global in nature.

I would just like to add one more point to those made by Dr. Speth about these issues of the future that are beginning to haunt us today. The statement from the recent Villach Conference on Assessment of Greenhouse Gases and Climate Change (sponsored by the United Nations Environmental Programme, the World Meteorological Organization, and the International Council of Scientific Unions) notes that the global and continental environmental issues involving the atmosphere are closely interrelated, both in their nature and in their causes and potential solutions. Take the three best-known of these: climate warming due to increases in carbon dioxide (CO_2), chlorofluorocarbons (CFCs or freons), and other greenhouse gases in the atmosphere; acid deposition; and threats, due to CFCs and other contaminants, to the stratospheric ozone layer that protects all living things from excessive ultraviolet radiation from the sun.

A reduction of fossil-fuel consumption through energy conservation or through a shift to other energy forms could not only reduce acid deposition in severely affected areas of Europe and eastern North America, it could also slow the rate of increase of atmospheric CO_2 and the accompanying climate warming. Similarly, reductions in CFC discharges to the atmosphere (from refrigeration and spray-can uses) would help to protect the stratospheric ozone layer as well as reduce the rate of climate warming. We must avoid tackling these problems in isolation and see their interrelationships both in understanding the processes and in seeking solution. At the same time, the social and economic consequences of these man-made changes in atmospheric composition must be better understood, as must the costs of control measures and impacts on international trade and competitiveness.

This latter thought leads me to suggest, as we near the end of this conference, a few proposals for follow-up action on our fascinating discussions over these two days. First, it seems clear that Simon Reisman should be an environmentalist – or at least a climatologist. As we enter negotiations of a freer trade with the United States, we are embarking upon arrangements that will have their greatest impact in the next few decades. But it now seems highly probable that climatic warming will make it possible for Canadian agriculture to gradually become much more diversified; forests will grow faster and more luxuriantly, except in areas adversely affected by acid deposition; and water regimes will change. Canada's negotiating strategy should take these probabilities into account, just as we should take into account the disparities brought about by different environmental regulation and by transboundary pollution problems, where economic benefits accrue in one country and economic and environmental disbenefits in the other. I would urge that the Economic Council or another suitable body undertake studies of the implications of environmental issues and climatic change on Canada's negotiating posture. Trade negotiations that ignore the all-too-free trade in pollutants, ignore an important economic factor.

Institutional arrangements to ensure better environmental input to economic decisions, and the reverse, have been extensively debated during these two days. Some have suggested an independent, authoritative environmental council to advise the government as a whole and not just the Minister of Environment. Some prefer a joint economic and environmental council. Others have suggested a Cabinet process at both federal and provincial levels, in which the environmental aspects of proposals for economic activities must be clearly outlined before Cabinet decisions are taken. The implication of other remarks is that each economic government department and each large private company should have an environmental unit to ensure that environmental concerns are built into the earliest planning stages of projects or programs. There are other options. The Economic Council, or perhaps the Institute for Research on Public Policy, should evaluate various options for ensuring that environmental aspects in their broadest sense become factored into regional and national economic decision making.

Finally, it seems clear that the environmentalists have much to learn from the economists about the development and presentation of indices showing improvement or decline. Economists and the media speak frequently of the GNP, the GDP, the balance of trade, the CPI, seasonally adjusted unemployment, and so on. But where is the index that says our water is less drinkable this year than last, or the air more breathable? Where is the index that says how much net gain or loss of soil and soil nutrients took place, or whether our national standing stock of trees has increased or declined? These are just as important to many Canadians as are the usual economic indicators, but environmentalists have never gotten on track to express these factors in simple terms. We need help from the economists to learn to do this effectively. In fact, one cannot help but be struck by the great need to have economists and environmentalists work much more closely together than they have in the past. I believe that such cooperation will be essential if Canada is to achieve a sustainable economic development in the face of national, regional, and global environmental problems.

Comments by W. R. Derrick Sewell

Good afternoon, ladies and gentlemen! Welcome to this extraordinary general meeting of CAMA (better known as the Canadian Association of Marriage Arrangers). It was called at the request of the Economic Council of Canada when it discovered two seemingly incompatible partners in bed together. Here was a flashy suitor called "economic development" set beside a tender mortal called "environmental integrity." Eyeing each other, they were uncertain that they could cope. They were faced in particular with two very practical questions: Is it possible to enjoy the bed for more than a fleeting moment? What should they do about the numerous relatives at home and abroad?

We understand from our roving ambassador Jim MacNeill that the two partners have been in bed together for some time and in various places. Until recently, however, they have either ignored each other completely, or have been able to live in sin without concern on the part of anyone. Pressures, it seems, are now growing for them to formalize the arrangement. Believing that a set of rules is required for this purpose, the Council wisely called in the Association.

As the papers presented at this meeting have emphasized, the difficulties of fostering and facilitating a lasting arrangement on the domestic scene are formidable. Normally in Canada the only way in which economic development and environmental integrity express feelings for each other is through confrontation, often with a high degree of hostility. Moreover, the relatives of each partner would never sanction anything beyond a brief flirtation. This attitude is reflected (and fostered) in the way that the relevant government agencies treat each other when economic and environmental issues are discussed. Mistrust and protection of turf are the typical starting points and usually the finishing points too. There is evidence in some parts of Canada that the two partners can get along well together. Prince Edward Island is perhaps the best example. For the most part, however, economic development and environmental integrity are firmly entrenched in opposite camps, unwilling to recognize the possibility that they need each other. It is evident, however, that such independence cannot be maintained much longer. The case for weldlock is becoming stronger every day. The question is no longer *if*; it is *when* and *how*?

How about the matter of the overseas relatives? Canada is a major trading nation. It also has a reputation for being a caring nation. Its activities overseas have made its officials and representatives acutely aware of the 10 items on Gustave Speth's "New Agenda." Unless something is done to formally recognize the link between economic development and environmental integrity, he argues, disaster on a global scale is inevitable. Speth's analysis of the emerging situation is articulate and persuasive. He tells us in particular what the U.S. is doing and what moves are being made on the international front. His analysis stimulates Canadians to ask: where do we go from here? What specific steps do we need to take to avoid the collapse he so vividly foresees?

Obviously, within the time available here it is impossible to furnish a detailed prescription. I will confine myself to a few suggestions as to what might be done in three particular connections: raising public awareness; actions by existing agencies; and preparing for the future.

In democratic societies, action generally comes from public pressure. A prerequisite, however, is a recognition that there is a problem to be solved. At present the problems identified by Gustave Speth are only dimly perceived by the public at large. For most people, concerns are focused on local, immediate issues, typically seen in isolation from each other and unconnected to the outside world. The Third World is a long way away and the government is usually seen as doing whatever this country can afford to do about the problems of far-off lands. Inquiries such as the Global 2000 review in the United States, or the Brandt Commission have drawn attention to the emerging global issues. Only a small technical elite, however, is acutely aware of them. Few members of the public would be willing or able to wade through the huge reports of the inquiries. Unfortunately, there is little other publicity on the matters they discuss.

A much more enlightened approach to raising awareness is needed. There are a few excellent examples in this regard. *The Gaia Atlas of Planet Management*, edited by Norman Myers, is one of them. It is extremely well written and superbly illustrated. Virtually anyone can gain an instant appreciation of its message. The reader is invited, for example, to consider the problem of death from malnutrition faced by some 40 million of the world's population. To provide a perspective a drawing of a jumbo jet is presented with a caption that says that such deaths are equivalent to 300 crashes of such an aircraft each day with no survivors. The message is clear and based on fact. It is understandable and credible.

Books are only one avenue. Other means of arousing awareness are needed too, especially amongst the young. How about sponsoring a poster competition to highlight the need for "sustainable development?" The award would be a substantial one and might be given to the winner's school as well as the winner himself. It could be offered by the Economic Council of Canada.

Another possibility would be to design a symbol to which a broad range of individuals might relate. Smoky the Bear delivered the message for fire prevention in North American parks. The Panda is now doing wonders for wildlife preservation. Who has got some good ideas about an appropriate cuddly symbol for sustainable development?

The Economic Council showed considerable imagination in organizing the present meeting. It should, however, be regarded as a *first* step in a process. The next one should be for the Council to explore in much greater depth the problem of marrying economic development and environmental integrity. Studies should now be undertaken to identify where such a union is needed most urgently, what specific policies and administrative arrangements would be required to put it in place, and what would be the consequences for various groups and sectors of the adoption of such a philosophy. This exploration would clearly benefit from interaction between Council researchers and a wide variety of groups within and beyond government. The Council should arrange for such interchanges.

A second useful step would be to encourage the establishment of an environmental council, styled perhaps along the lines of the Economic Council. It would have a high profile, and would be an independent body directly responsible to the government. It would be supported by a secretariat and would have sufficient funding to enable it to carry out its tasks. Its mandate would be to provide advice on issues referred to it by the government, but would also identify matters that need to be reviewed beyond the immediate needs of the latter. It would have strong ties with the Economic Council.

A third move would be to show the world that Canada really does believe in the philosophy of "sustainable development." Overseas, Canada enjoys a reputation as a country that is highly committed to the promotion of environmental integrity. This stems in part from Canada taking a lead role with respect to the organization of various UN Conferences, the introduction of a world conservation strategy, and more recently, the establishment of a World Commission on Environment and Development. It also results in part from the fact that CIDA is vitally interested in the environment. This year, it is funding environmentally related projects costing a total of more than $300 million. Beyond this, Canadian environmental experts are called upon for advice all over the world. Promotion of a philosophy of "sustainable development" will doubtless bring further calls for Canadian aid and expertise. We should be ready to respond.

Understandably, most of the discussion at this meeting has focused upon the problems of the present. These are clearly urgent and merit our immediate attention. But the world is changing rapidly. We cannot expect the world of 2005, or less still that of 2025, to be very much like that of 1985. What kinds of institutions will we need to cope with the inevitable changes in technology, economic activities, and social values? Will we need something other than the Economic Council and Environment Canada a decade from now? What roles will the various economic development, resources, and environmental management agencies be expected to play? The Economic Council should clearly give a high priority to such questions. Obviously, the relevance as well as the viability of a philosophy of sustainable development hinge upon the kind of future to which we have to respond.

Table 9-1

Old and New Experts in Planning

Old expert	New expert
SOLUTION ORIENTED (defines a problem in terms of a solution)	PROBLEM ORIENTED (explores a situation to define the problem)
- Bounded	- Unbounded
- Emphasis on primary effects	- Secondary and tertiary effects
- Simplifying	- Complexifying
- Assumption accepting	- Assumption challenging
QUESTION ANSWERING EXPERTISE	QUESTION ASKING EXPERTISE
- Professional	- Extra professional
- Error denying	- Error embracing
- Surprise free	- Surprise embracing
SYSTEM CLOSING	SYSTEM OPENING
- Elitist	- Democratic
- Technocratic	- Public
- Comforting	- Threatening
- Conflict masking	- Conflict exposing
- Product oriented	- Process oriented
ORGANIZATION CAPTIVE	BOUNDARY SPANNING
- Protected	- Exposed
- "Hired Gun"	- Free floating
- Institutional	- Personal
- Client oriented	- Issue opportunistic
POLITICALLY EXPLICIT	POLITICALLY AMBIGUOUS
- Late in political process	- Early in political process
- Choice related	- Issue formulating
- Well-defined expectations	- Uncertain expectations

SOURCE Adapted from D. N. Michael, *On Learning to Plan and Planning to Learn*, Jossy-Bass, San Francisco, 1973.

The Council should also address the question of what kind of experts will we need. The answer to the latter is not clear. It is interesting to consider, however, a characterization of old experts with those of tomorrow, as suggested by Donald Michael (Table 9-1). Each of us would do well to ask ourselves: Which group are we in now? And would we be willing and able to move from the Old to the New? The Council in turn would do well to consider the implications of keeping the old experts versus those of fostering the introduction of new ones.

In summary, then, we have two strange bedfellows in Canada representing development and environment. The Economic Council sees marriage as desirable and inevitable. The Canadian Association of Marriage Arrangers accepts this view. It believes, however, that we still have some work to do before the alliance can be satisfactorily consummated. The Council should accept that challenge and give it the highest possible priority.

Enfin, pour le Conseil économique du Canada il y a beaucoup de travail à faire, soit de construire un lit si confortable que les occupants ne voudront jamais en sortir.

Floor Discussion

Comment: In my opinion the environmentalist and the economist do not yet speak the same language, and more clarification is required. There are three areas where economists and organizations such as the Economic Council might focus their efforts. First, economists have long been recommending that environmental services be priced to reflect full cost. We need to investigate the political impediments to the implementation of this approach and explain why the advice is so often ignored. Second, we need to plan for environmental change. The impact of climate change on the viability of major economic sectors in Canada could be studied. And we should try to determine which fields will require indicative planning, because decentralized decision making cannot be relied upon to cope with environmental change. Can agriculture, for example, respond appropriately to climate change?

Third, the consequences of environmental change on the distribution of income merit scrutiny. Canada has, after all, considerable experience with redistribution issues.

Comment: Experts are important in resolving environmental issues, but we also need an integrated way of coming from the grass roots up. Environmental groups have been particularly active at public consultation. In Alberta we are trying, by means of a consultative process, to bridge developmental and environmental points of view and devise a provincial conservation strategy complementary to the global one.

Comment: When the concept of a conserver society was being debated in Canada, there was criticism that its adoption by the West would undermine Third World countries because our growth would slow down and also our demand for imports. On the other hand, Canada has been urged to manage its natural resources better in future, not only for our own benefit but also to share throughout the world. We need to clarify our thinking about the husbanding of resources in Canada and sustainable global development.

◆

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Program of the Colloquium on the Environment

Toronto, Ontario
December 9-10, 1985

Monday, December 9

Opening Remarks

Judith Maxwell
Chairman
Economic Council of Canada
Ottawa

International Perspectives

Chairperson

C. S. Holling
Institute of Animal Resources Ecology
University of British Columbia
Vancouver

Speaker

James W. MacNeill
Secretary General
World Commission on Environment
and Development
Geneva

Discussants

Colin F. W. Isaacs
Executive Director
The Pollution Probe Foundation
Toronto

André Marsan
President
André Marsan & Assoc. Inc.
Montreal

Fresh Water Issues

Chairperson

Bruce W. Mitchell
Professor of Geography
University of Waterloo
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Speaker

Peter H. Pearse
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Inquiry on Federal Water Policy
Professor of Forest Economics
University of British Columbia
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Discussants

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Jean-Louis Sasseville
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INRS-Eau
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Luncheon Address

Speaker

The Honourable Thomas M. McMillan
Minister
Environment Canada
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Chairpersons

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Yves Guérard
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Member of the Economic Council of Canada

Forest and Wildlife Management

Chairperson

David W. Slater
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Speaker

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Discussants

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Université Laval
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Management and Disposal of Toxic Wastes

Chairperson

Douglas Macdonald
Executive Director
Canadian Environmental Law Research Foundation
Toronto

Speaker

Donald A. Chant
President and Chairman
Ontario Waste Management Corporation
Toronto

Discussants

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Westwater Research Centre
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Pierre Grenier
Vice-President, General Manager
Stablex Canada Inc.
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Dinner Address: Dams and the Environment

Speaker

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Tuesday, December 10

Air Quality and the Energy-Environment Interface

Chairperson

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Guelph

Speaker

F. Kenneth Hare
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Discussants

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Adjunct Professor, Environmental Studies
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Environmental Preservation and Economic Growth

Chairperson

Donald N. Dewees
Professor of Political Economy
University of Toronto
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Speaker

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Discussants

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Luncheon Address

Speaker

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Chairpersons

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Addressing Environmental Issues in the Future

Chairperson

Pierre Dansereau
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Speaker

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Discussants

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Environment Canada
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W. R. Derrick Sewell
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Closing Remarks

Judith Maxwell
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